JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

VOL. 38 June, 1945 No. 3

Large Scale Power Dusting of Feeder Lambs for Winter Control of the Sheep Tick[1,2]

JOHN G. MATTHYSSE, *Cornell University, Ithaca, N. Y.*

Every winter many thousands of western range lambs are brought into western New York to be fattened over a three to four months period before going to slaughter. Practically all such lambs are infested with the sheep tick *Melophagus ovinus* (Linn.), and very often carry extremely heavy populations of this parasite (Figs. 2, 6). The consensus of opinion is that feeder lambs now arrive from the western states with heavier "tick" infestations than in earlier years. Most feeder lambs are not treated for "ticks," but some are dipped, some hand dusted, and some even "poured." This latter method consists of placing the lamb in a trough and pouring on the dip from a bucket, and catching the drainings from the end of the trough. Dipping and "pouring" are both very effective, but not practical under cold weather conditions. Most feeder lambs are shipped in late November, December, and even January when a wet treatment would often do more harm than good. This last winter there were no warm days after the end of November, so that very few lambs could be safely dipped or "poured." Dust treatments by hand are effective if thoroughly done, but very time consuming and unpleasant. Some lamb feeders even shear the lambs to reduce "tick" infestations late in the feeding period.

With these conditions in mind an attempt was made to develop a large scale method of dusting lambs. A small "Cropmaster" type 8 nozzle one half horsepower duster was tested but found inadequate to drive dust deeply into the wool. The Niagara Sprayer and Chemical Company then very kindly loaned a *Dri-Fog*, 5 horsepower, 18 nozzle, crop duster that proved to be well suited to the purpose. A special chute was built by which the lambs could be run rapidly past the nozzle ends (Figs. 2, 3). The chute was made in two sections, each section 8 feet long and 30 inches high. The second section, carrying the duster head was only 10 to 12 inches wide. The first section, where the lambs entered, was varied in width according to the conditions of the barn in which the lambs were fed, but was usually at least 20 inches wide at the free end and 12 inches wide where it was hooked onto the second section. The duster head (Fig. 4) was fashioned by drilling fifteen two inch holes in the two by four uprights and the cross piece at the free end of the second section. The ends of the flexible

FIG. 1.—Typical feeder lamb, heavily infested with sheep ticks. Note the stingy, pulled, dirty fleece.

[1] This is a report on an investigation carried on by the Department of Entomology, of the New York State College of Agriculture under a fellowship provided by the Agricultural Department of the Texas Gulf Sulfur Company, Houston, Texas.

[2] Early publication has been secured by payment of the costs of printing.

duster tubes were held in place in these holes by means of set screws. The nozzles were simply the open ends of the flexible duster tubing. It was found that any compressed or fishtail type nozzle decreases the velocity too greatly for good

FIG. 2.—The duster and chute set up ready for operation. Note that the duster remains on the truck, only the chute is moved so that assembly is rapid.

penetration. The nozzles were evenly spaced, six on each side, and three above. The bottom nozzle on each side was directed upwards so that the undersides of the lambs were also dusted. Three outlets of the duster were not used, these were plugged. The nozzles were thus all in one

FIG. 3.—The duster and chute in operation. If a line of lambs is kept moving through the chute the machine can be run continuously at full capacity.

vertical plane at the end of the chute, arranged so that the whole body was dusted at once as the lamb ran between the nozzles. This end of the chute should be as narrow as possible so that the nozzles are close to the wool. The rig as finally worked out was designed so that a large number of lambs could be run through in a short time, and the whole was easily portable and quickly set up at each farm. In most cases the lambs were in carload or half carload lots in barns in which they were fed. The chute was set up at the barn door and the lambs run out through the chute as fast as it was possible to move them.

It is thought that in actual control operations as many as 2000 head may be dusted in one day, and perhaps many more. Under experimental conditions over 1400 were dusted in about six hours. It is possible to set up the dusting chute, dust one or two cars of lambs (300 to 600), pack the outfit back onto the truck, and drive off within two hours. Much depends on the efficiency of the set up; if the lambs will not run through the chute of their

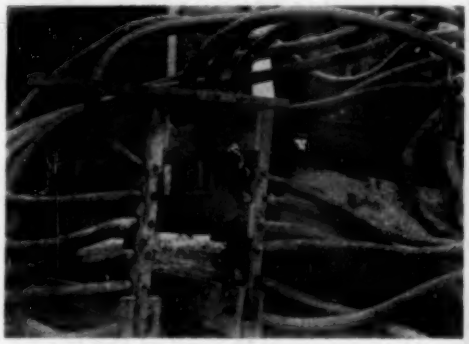


FIG. 4.—The duster nozzle head at the end of the chute. Note the bottom nozzles pointing upward.

own accord, but require much handling, then considerably more time and labor will be necessary, and more dust. If the lambs run through the chute well the duster can be operated continuously at full capacity until all the lambs are dusted.

The control achieved by this power dusting method has been surprisingly good (Fig. 6). In all cases where a rotenone dust has been used under favorable conditions perfectly satisfactory control has resulted for the duration of the feeder period by a single treatment. The mortality of adult ticks was over 90 per cent one week after dusting, and the rotenone remained effective long enough to kill most of the ticks emerging from pupae present in the wool at the time of dusting. The pupae were not affected by the dusts used. There have been no reported ill effects to the lambs or to the operators.

Several of the dusts were temporarily irritating to the eyes and throat of the operators, but this objection has been overcome by the use of pyrophyllite as the diluent for rotenone, and the addition of oil to the dust.

The procedure in evaluating the dust treatments was to take mortality counts two days after dusting, and at odd intervals thereafter during the feeding period. These counts were taken by rapidly counting all dead and live "ticks" seen while parting the wool on both sides of the body. The time required for this examination was less than two minutes. This counting method gave a good comparative picture of the "tick" population and the mortality, but the total "tick" populations were undoubtedly several times this figure. Most of the counts of live "ticks" subsequent to two days after dusting were subdivided into "ticks" obviously several days old, and "ticks" very recently emerged from pupae. It is considered that these recently emerged "ticks" had not had sufficient exposure to the dust, so that the per cent mortality considering only old live "ticks" is probably the more significant data.

The dusts used contained either rotenone, or DDT. All cube root used contained 4.8 per cent rotenone. The following finished dusts were tested:

FIG. 5.—Duster and chute packed onto the truck ready to move to another farm.

Cube 1 part, *Pyrax ABB* 10 parts
Cube 1 part, Wettable Sulfur 10 parts
Cube 1 part, Bentonite-Sulfur (Fine-X) 10 parts
Cube 1 part, *Pyrax ABB* 20 parts
Cube 1 part, *Pyrax ABB* 10 parts, 2 per cent #10 motor oil added DDT dust, 5 per cent (*Neocid A 5*)

The 1 to 10 cube *Pyrax* dust containing 2 per cent of motor oil was the most effective treatment. The mortality within 2 days was 89 per cent or over in all cases except one where the lambs were wet. All other dusts yielded less than 80 per cent mortality. The residual effect was also superior after one month averaging 90 per cent mortality and only 2.6 ticks per lamb whereas other rotenone dusts varied from an average of 76 to 86 per cent mortality, and 2.7 to 7.7 ticks per lamb. The addition of oil to rotenone dust was desirable also from the standpoint of reducing the irritation to the operators. The oil weighted down the dust so that far less cloud was produced in the air around the barns, and it became possible to work without even using dust masks.

FIG. 6.—Dead sheep ticks in the fleece of a dusted lamb. More than 40 could be counted in this one parting of the wool.

The 5 per cent DDT dust was not effective. The mortality was low (7 per cent) and the residual effect very slight. The tick population built up to a higher level in 100 days than on any of the rotenone dusted flocks.

The check flocks indicated that the tick populations would build up during the feeding period, so that the population reductions after rotenone dusting were due to the dusting.

The conditions under which the lambs were fed had a marked effect on the dusting results. Lambs fed outdoors have very little grease in the wool, whereas lambs fed indoors in tight barns are extremely greasy. There is less grease in the wool if the barn is well ventilated or of open

construction. In general control was superior where the wool was greasy, that is when lambs were fed indoors in tight barns. It was found that penetration was very poor if the lambs were wet when dusted, in several instances lambs very recently out in snow and rain were treated, but with poor results.

No significant differences were noted among the diluents tested. It was found that sulfur is not practical as the irritation to the eyes of the operators was intense. The bentonite-sulfur was even more irritating than the wettable sulfur. Pyrophyllite was only very slightly irritating.

It will be noted in the table that, even more than three months after dusting, the rotenone dusted lambs carried a population, by rapid counts, of less than ten "ticks" per lamb in all cases, and in most cases less than four "ticks" per lamb. This residual population is too low to cause damage to feeder lambs, but does mean that the method would not be applicable to ordinary farm flocks where actual eradication of "ticks" is desired and can be accomplished by dipping. In most of the replicates there was an increase in the tick population toward one month after dusting, and a subsequent decrease. It is

Table 1.—Large scale power dusting of feeder lambs for winter sheep tick control. Batavia, N. Y.—1945.
All cube root contained 4.8% rotenone.

Dust	Feeding Conditions	Lambs	Sheep Ticks Per Lamb Before Dusting*	Per-Cent Mortality in 2 Days	Residual Effect During Feeding Period			
					Days After Dusting	Per Cent Mortality Old[2] Ticks	Per Cent Mortality All[2] Ticks	No. of Live Ticks Per Lamb[1]
Cube 1 part *Pyrax ABB* 10 parts	Indoors Tight barn	130	11	67	8	—	91	1.0
					18	100	88	0.6
					80	—	—	0.0
					106	—	—	0.0
	Outdoors	310	18	76	18	98	92	1.0
					26	92	83	3.8
					101	—	—	8.1
	Indoors Ventilated Dry barn	320	36	79	12	99	88	2.8
					74	—	—	2.5
					100	—	—	4.0
	Indoors Tight damp barn	355	21	69	12	97	92	1.3
					74	—	—	0.3
					100	—	—	0.4
	Indoors Tight barn	200	51	63	11	92	77	7.7
					24	79	49	18.0
					72	—	—	2.6
					100	—	—	2.1
	Indoors Ventilated barn	311	29	75	7	95	91	1.6
					37	99	96	1.4
					73	—	—	3.0
					100	—	—	0.4
Average (Approx.)		1626	26	72	15	97	89	2.3
					30	90	76	7.7
					75	—	—	1.5
					100	—	—	2.5
Cube 1 part, Wettable sulfur 10 parts	Barn and barn lot	360	13	69	12	95	85	2.4
					100	—	—	7.8
	Barn and barn lot	380	29	74	25	96	79	5.2
					74	—	—	1.4
					100	—	—	9.8

Table. 1.—*continued*

Dust	Feeding Conditions	Lambs	Sheep Ticks Per Lamb Before Dusting*	Per Cent Mortality in 2 Days	Residual Effect During Feeding Period			
					Days After Dusting	Per Cent Mortality Old[2] Ticks	Per Cent Mortality All[2] Ticks	No. of Live Ticks Per Lamb[1]
Average (Approx.)		740	21	72	12	95	85	2.4
					25	96	79	5.2
					74	—	—	1.4
					100	—	—	8.8
Cube 1 part, Bentonite-Sulfur 10 parts	Indoors Very open barn	400	26	75	4	—	80	3.2
					13	97	91	2.5
					26	97	86	2.7
					75	—	—	2.0
					101	—	—	3.0
5% DDT on Pyrophyllite	Indoors tight barn	300	4	7	11	47	39	3.4
					24	43	22	4.2
					73	—	—	8.4
					100	—	—	14.0
Cube 1 part *Pyrax ABB* 20 parts	Indoors tight barn	150	23	68	49	95	91	1.2
					77	—	—	2.4
	Indoors Ventilated barn	165	25	72	77	—	—	3.2
	Barn and barn lot Lambs wet	325	12	51	49	54	46	7.7
					77	Sold		
	Indoors tight barn	450	31	69	77	—	—	1.9
Average (Approx.)		1090	23	65	49	75	69	4.5
					77	—	—	3.8
Cube 1 part, *Pyrax ABB* 10 parts 2% of No. 10 motor oil	Barn and barn lot Lambs wet	250	24	74	28	—	75	5.0
	Indoors tight barn	500	24	96	28	—	96	0.9
	Barn and barn lot Lambs wet	280	55	89	28	—	88	5.1
	Indoors tight barn	120	17	93	29	—	92	1.4
	Indoors tight barn	515	32	—	27	—	97	0.9
	Indoors tight barn	318	31	—	26	—	94	2.0
Average (Approx.)		1983	31	88	28	—	90	2.6
Checks	Indoors tight barn	300	5	—	70	—	—	12.0
					97	—	—	18.1
	Indoors Ventilated barn	500	—	—	90	—	—	17.0
Totals	22 Flocks	6939 Lambs						

[1] Rapid counts, less than 2 minutes per lamb, actually serveral times this number of insects per lamb.
[2] Counts subsequent to 2 days after dusting were divided into sheep ticks obviously several days old, and those very recently emerged from pupae. It is considered that these young ticks had not had sufficient exposure to the dust, so that per cent mortality of old insects is the more significant data.

thought that this increase is due to the emergence of a large number of adults from pupae about one month after dusting as the pupal period lasts close to one month during the winter. The rotenone is less effective toward the end of the emergence period, so that more survive, but subsequently there is practically no emergence, and most of the adults are gradually killed off by the residual rotenone.

The cost of treating lambs by this dusting method is less than for dipping. Approximately 700 lambs can be treated with 100 pounds of dust. The cost of materials is thus approximately one cent a head. Less time is required, and less labor than in dipping.

The actual initial cost of the dusting machine is fairly high, but it is not high when the very large number of lambs that one machine can dust is taken into consideration. The cost of the duster is easily within the means of cooperative county or other organizations such as now operate dipping rings and spray rings.

SUMMARY.—Power dusting offers an easy, rapid, and very effective method of controlling sheep ticks on feeder lambs. This method was devised for cold weather conditions, when dipping is injurious to the lambs. It is less expensive and quicker than dipping, and non-injurious.

The lambs are run through a chute past a bank of duster nozzles. A high powered machine such as a 5 horsepower, 18-nozzle, crop duster is necessary. Under commercial conditions probably 2000 lambs could be dusted in a day, at a cost of materials of about one cent a head.

The most effective dust used was a mixture of 1 part cube root (4.8 per cent rotenone), 10 parts of *Pyrax ABB* with 2 per cent of No. 10 motor oil added. This dust yielded over 90 per cent kill of ticks in 2 days and there was very little subsequent reinfestation during the feeder period. Dusts containing sulfur were too irritating to the eyes of the operators to be practical. DDT was not effective. The rotenone oil dust in all cases gave very satisfactory "tick" control and in no case were any ill effects to the lambs or the operators reported. Inclusion of the oil weighted the dust and reduced the dust cloud so that rotenone irritation to the operators was very slight.—4-15-45.

CUPRIFEROUS CEMENT AS A ROACH REPELLENT

Investigational findings reported by Mellon Institute, Pittsburgh, Pa., demonstrate the repellency of the floor surfacing material *Hubbellite*, a cupriferous cement, to German, American, and Oriental roaches. These results are of significance to food manufacturers, our armed forces, restaurants, hotels, institutions, and also home managers.

Glass aquaria having a 2-gallon capacity served as test chambers. In preliminary tests one half of each was floored with gray-colored *Hubbellite*, the other half with Portland cement. Food and water were provided in each half, the roaches introduced and the aquaria placed in absolute darkness. Observations and counts of distribution were made at 24-hour intervals. Several aquaria serving as controls were entirely floored with either Portland cement or *Hubbellite*. The data from preliminary tests clearly indicate the repellency of *Hubbellite* to all three species of roaches, with a more marked efficiency exhibited against the German roach.

In a second series of tests food or water or both were removed from the Portland cement side of the aquarium to determine the degree of repellency. Findings from this series of tests indicate a positive repellency for all three species. However, the percentage of roaches found on the *Hubbellite* was lower for the German roach than for the American or Oriental species. In brief, the presence of food or water or both on only the *Hubbellite* side failed to cause a significant increase in numbers in this half of the test chamber.

In the final series of tests green, brown, and red *Hubbellites* were used as flooring materials to determine their relative repellency in relation to gray *Hubbellite*. The results show gray, brown, red, and green *Hubbellite* to be equal in effectiveness against the German and American roach, while gray *Hubbellite* was more efficient than brown, red, and green against Oriental roaches.

Increased Toxicity of Lime-Treated Sabadilla Seed[1] in Dust Suspensions

T. C. Allen and L. K. Brunn, *University of Wisconsin, Madison*

Results of recent tests with kerosene extracts of sabadilla against the housefly, *Musca domestica* Linn (Allen *et al.* 1944) have shown that the application of heat and/or alkali is of considerable value in increasing the toxicity of oil extracts of freshly powdered seed to this insect. The increased effectiveness was obtained by extracting with kerosene at high temperature, e.g. above 125° C., or by treating the seed previous to extraction with either alkali or heat. No attempts were made to determine the significance of these treatments upon powdered seed when applied in dusts or sprays for controlling insects. The present studies were made to determine whether heat or alkali treated seed might be employed to an advantage in dusts for controlling other insects.

Methods and Procedure.—The large milkweed bug, *Oncopeltus fasciatus* (Dallas), and the red-legged grasshopper, *Melanoplus femur-rubrum* (DeGeer), were employed as the test insects in these studies. Preliminary tests had shown that the former insect is very susceptible to sabadilla. It was possible to develop a procedure whereby large numbers were easily reared under laboratory conditions. The rearing methods employed for the insect were adopted from those described by Andre (1934), Simanton & Andre (1935), and Worthley (1943). Large numbers were built up so that populations of 400 to 500 bugs 10 days old were available each day for testing purposes. The time required to rear such numbers of insects was reduced materially by obtaining a large supply of cleaned milkweed seeds from a commercial source.[2]

Twenty ten-day-old adult bugs were used in each test. Prior to testing, the bugs were removed from the culture jars and placed in small wire screen cages. They were then subjected to 500 mgs. of dust under a bell jar of 1.25 cu. ft. capacity. Following treatment the insects were transferred to clean cages. Fresh supplies of milkweed seed and water were provided during the period of observation.

Grasshoppers collected from the field were placed in cages and subjected to a similar testing procedure.

Mortality was recorded 24 and 72 hours after treatment. Preliminary trials indicated that those insects receiving sublethal or lethal dosages either recovered or succumbed to the treatment by the end of the 72-hour observation period.

As shown by Allen *et al.* (1944) heat or alkali increased the effectiveness of kerosene extracts of sabadilla seed. In parallel treatments of the seed to determine the possible efficiency of sabadilla dusts, variously treated dusts were prepared for testing purposes. The heat treatment used to activate sabadilla consisted of heating the coarsely ground seed (30 mesh) in an oven for 4 hours at 75 to 80° C. The material was then cooled and finely powdered with *Pyrax*[3] for testing against the insects. The alkali treatments involved: (1) moistening the coarsely ground seed with a 10 per cent solution of sodium carbonate at the rate of 20 cc. per 100 grams of seed, drying and milling with *Pyrax* and (2) milling the coarsely ground seed with a high calcic lime.

Results.—It was necessary to dilute the dusts to a level of less than 1 per cent sabadilla to evaluate the differences between the various treatments.

Table 1-A records the toxicity of the 1 per cent sabadilla dusts against the milkweed bug indicating that all samples of treated and untreated sabadilla were highly toxic. Neither the *Pyrax* nor the lime used in milling the dusts showed appreciable toxicity to the test insects. At the 0.75 per cent level (Table 1-B) identical dusts produced lower kills and showed greater differences in expression of toxicity. Results of these tests show that the highest percentage of kill occurred in lime-milled samples. This was consistent whether the sabadilla concentrate prepared by milling with lime was diluted with *Pyrax* or with lime.

The comparative toxicity of the heat-

[1] Approved by the Director of the Wisconsin Experiment Station.

[2] Milkweed Floss Corporation of America, Petoskey, Michigan.

[3] The term *Pyrax* as used in this paper refers to *Pyrax ABB*.

treated, soda-ash treated and the lime-milled sabadilla samples is shown in tables 1-C and 1-D. The differences in toxicity of the various treatments are expressed more significantly at the 0.75 per cent sabadilla level than at the 1 per cent level.

Tests comparing the toxicity of a 1 per cent sabadilla dust activated by preparing the concentrate with lime with pyrethrum and DDT dusts are shown in Table 2. It is evident that this sabadilla dust was more toxic to the milkweed bug than either a 0.1 per cent pyrethrins or a 2 per cent DDT dust.

Additional tests were made (Table 3) to confirm the relative efficiency of lime-treated sabadilla against adults and nymphs of the red-legged grasshopper. Here again the lime-treated sabadilla employed at 20, 10 and at 5 per cent concentrations was more effective than the same concentrations of the untreated seed.

Table 1.—Laboratory tests of treated and untreated sabadilla dusts against the large milkweed bug.

Treatment[1]	Number of Bugs	Mortality Hours 24	Mortality Hours 72	Average Per Cent
A	120[2]	0	1	1
B	120	1	5	5
C	120	107	119	99
D	120	115	120	100
E	120	52	119	99
F	120	15	72	60
Check	120	0	0	0

A—Dusted check; 1% lime, 99% *Pyrax*.
B—Dusted check; 1% *Pyrax*, 99% lime.
C—1% Sabadilla; ground with lime, diluted with *Pyrax*.
D—1% Sabadilla; ground with lime, diluted with lime.
E—1% Sabadilla; ground with *Pyrax*, diluted with lme.
F—1% Sabadilla; ground with *Pyrax*, diluted with *Pyrax*.

G	120[2]	2	8	7
H	120	46	90	75
I	120	45	106	88
J	120	89	120	100
K	120	46	87	75
Check	120	0	1	1

G—Dusted check; 0.75% *Pyrax*, diluted with lime.
H—0.75% Sabadilla; ground with *Pyrax*, diluted with lime.
I—0.75% Sabadilla; ground with lime, diluted with *Pyrax*.
J—0.75% Sabadilla; ground with lime, diluted with lime.
K—0.75% Sabadilla; ground with *Pyrax*, diluted with *Pyrax*.

A	200[3]	0	3	2
L	200	11	66	33
M	200	50	118	59
C	200	171	193	97
F	200	8	56	28
Check	200	1	3	2

A—Dusted check; 1% lime.
L—1% Sabadilla; heat-treated, ground with *Pyrax*.
M—1% Sabadilla; alkali-treated, ground with *Pyrax*.
C—1% Sabadilla; ground with lime.
F—1% Sabadilla; ground with *Pyrax*.

N	180[4]	1	1	1
H	180	76	136	76
P	180	15	73	41
O	180	2	16	9
K	180	6	45	25
Check	180	2	2	1

N—Dusted check; 0.75% lime.
H—0.75% Sabadilla; ground with lime.
P—0.75% Sabadilla; alkali-treated, ground with *Pyrax*.
O—0.75% Sabadilla; heat-treated, ground with *Pyrax*.
K—0.75% Sabadilla; ground with *Pyrax*.

[1] *Pyrax ABB* used as diluent in all dusts.
[2] 6 replicates per material, 20 bugs per replicate.
[3] 10 replicates per material, 20 bugs per replicate.
[4] 9 replicates per material, 20 bugs per replicate.

Table 2.—Laboratory tests of treated sabadilla, DDT, and pyrethrum dusts against the large milkweed bug.

Treatment[1,2]	Mortality 24 hours	Mortality 72 hours	Average Per Cent Mortality
Dusted Check (1% lime)	0	0	0
Sabadilla (1%, lime-treated)	124	166	92
DDT, 2%	13	92	52
Pyrethrins, 0.1%	115	132	73
Check	0	4	2

[1] *Pyrax ABB* was used as the diluent in these dusts.
[2] 9 replicates for each material, 20 bugs per replicate.

Additional tests were made (Table 3) to confirm the relative efficiency of lime-

Table 3.—Laboratory tests of sabadilla dusts milled with lime and talc against the adult and nymph of *Melanoplus femur-rubrum* (De Geer).

Sabadilla	Treatment[1,2]	Knock-down 1 Hour	Mortality 24 hrs.	Mortality 48 hrs.	Per Cent Kill 48 Hours
		Adults			
20%	Lime	37	37	37	92.5
20%	Talc	30	33	33	82.5
10%	Lime	24	27	30	75.0
10%	Talc	7	8	12	30.0
5%	Lime	2	16	20	40.0
5%	Talc	1	2	4	10.0
Check		0	0	1	2.0
		Nymphs			
20%	Lime	19	30	36	90.0
20%	Talc	1	14	15	37.6
Check		0	0	1	2.5

[1] In milling the sabadilla seed it was first ground with 50 parts of the diluent.
[2] Forty insects for each treatment.

SUMMARY.—1. Tests against the large milkweed bug and the red-legged grasshopper show that the activation of sabadilla dusts appreciably increases the toxicity.

2. Heat or alkali in the form of a sodium carbonate solution or hydrated lime may be used for the activation of a sabadilla dust.

3. Preparation of a concentrate with hydrated lime or using this material as a

diluent in the dust is the easiest and most efficient method of activation.

4. High dosages of sabadilla will obscure the effects of activation.

5. The activation of sabadilla by heat or alkali treatment produces a dust having an increased toxic efficiency with a minimum amount of seed.—12-14-44.

LITERATURE CITED

Allen, T. C., R. J. Dicke, and H. H. Harris. 1944. Sabadilla, *Schoenocaudon* spp., With Reference to Its Toxicity to Houseflies. JOUR. ECON. ENT. 37(3): 400–8.

Andre, Floyd. 1934. Notes on the biology of *Oncopletus fasciatus* (Dallas). Iowa State Col. Jour. Sci., 9: 73–87.

Simanton, W. A., and Floyd Andre. 1935. Two Hemiptera for use as experimental insects in insecticide studies. JOUR. ECON. ENT., 28: 695–6.

Worthley, Harlan N. 1923. Large milkweed bug. Laboratory procedures in the studies of the chemical control of insects. American Association for the Advancement of Science, Washington, D. C. 31–33.

The Relative Effectiveness of the Principal Alkaloids of Sabadilla Seed[1]

T. C. ALLEN, KARL PAUL LINK, MIYOSHI IKAWA and L. K. BRUNN,[2]
University of Wisconsin, Madison

Studies of the insecticidal potentiality of kerosene extracts of sabadilla seed (Allen *et al.* 1944) have revealed that heated and alkali treated seed are highly effective in killing houseflies. Further studies of the isolated toxicants (Ikawa *et al.* 1945) when tested against houseflies have shown that the alkaloid veratridine is the most active principle of the seed. Other fractions, e.g. cevadine, veratrine,[3] and bases from the soluble dilturates of the chloroform eluate were toxic in kerosene to flies but at much higher concentrations. Cevine and the oil from sabadilla seed possessed nc toxicity.

As the total alkaloids of sabadilla are only slightly soluble in kerosene and since the toxicity of the constituents to houseflies were measured in kerosene solutions, a study was made to determine the relative toxicities of the sabadilla constituents in dust suspensions to certain insects. The insects employed in these tests were the milkweed bug, *Oncopeltus fasciatus* (Dallas) and the red-legged grasshopper, *Melanoplus femur-rubrum* (DeGeer). The toxicities of kerosene solutions of the sabadilla alkaloids to the milkweed bug were also determined.

A review of the insecticidal uses of sabadilla has been given (Allen *et al.* 1944). There are few reports on the use of the sabadilla alkaloids in dusts. Employed as a dust in flour, Bussy (1922) found veratrine and cevadine toxic to caterpillars of *Prodenia litura*, Fb. McAllister & Van Leeuwen (1930) have reported that apples dusted with the pure veratrine alkaloid were free from codling moth stings or entrances.

METHODS.—Essentially, the principal constituents of sabadilla as previously described in tests against the housefly (Ikawa *et al.* 1945) were used. These were veratrine, veratridine, cevadine, cevine, hydrochlorides of veratrine and the oil obtained by petroleum ether extraction of the seed. These materials were mixed at various dilution levels with an inert dusting powder, pyrophyllite.[4] Known dosages of the mixtures were then injected into a bell jar which contained the test insects.

Insects in wire screen cages were exposed to dust suspensions of 500 mgs. of insecticide in 1.25 cu. ft. of space for a period of 3 minutes. After the dust treatment, the insects were transferred to other cages and supplied with food and water. Observations and record of insect mortality were made over a 72-hour period.

The kerosene solutions were prepared by adding the sabadilla fractions to kerosene and heating on a steam bath to facilitate solution. The solutions were then cooled and filtered. The toxicities were measured using the procedure previously described by Allen *et al.* (1943) for house-

[1] Approved by the Director of the Agricultural Experiment Station.

[2] We wish to acknowledge the assistance of Miss E. Cole and Mr. J. Tollefson who carried out some of the biological tests.

[3] Veratrine refers to the alkaloid mixture obtained from sabadilla seed.

[4] *Pyrax ABB.*

Table 1.—Laboratory tests of the principal constituents of sabadilla in dust suspensions to the milkweed bug.[1]

Concentration of Toxicant	Knock-down 1 Hr.	Mortality in Hours 24	48	Percentage Kill
1–100	A			
Veratrine	35	40	40	100
Cevadine	39	40	40	100
Veratridine	21	40	40	100
Cevine	0	2	3	7.5
Hydrochlorides	23	40	40	100
Oil	0	0	0	0
Check	0	1	1	2.5
1–500	B			
Veratrine	1	22	36	90
Cevadine	39	40	40	100
Veratridine	0	16	17	42.5
Cevine	0	0	0	0
Hydrochlorides	0	8	14	35.0
Oil	0	0	0	0
Check	0	0	0	0
1–1000	C			
Veratrine	0	0	0	0
Cevadine[2]	3	33	35	94.3
Veratridine	0	0	0	0
Cevine	0	0	1	2.5
Hydrochlorides	0	1	1	2.5
Oil	0	0	1	2.5
Check	0	0	1	2.5

[1] Four repicated tests of 10 insects per test.
[2] Thirty-seven insects in test.

flies. Three cc. of the kerosene solution to be tested were atomized into the upper end of a bell jar and milkweed bugs in wire screen cages were exposed to the settling mist for a period of 2 minutes.

Adult and nymphal grasshoppers were collected from heavily infested alfalfa fields for testing purposes. They were subjected to the dust treatments immediately upon collection, and following treatment they were supplied with alfalfa foliage and water. Tests were made over a 6-week period.

Table 2.—Laboratory tests of cevadine in dust suspensions to the milkweed bug.[1]

Dust Dilution	No. Insects	Knock-down 1 Hr.	Mortality 24 hrs.	48 hrs.	Percentage Kill
1:100	40	6	40	40	100
1:500	40	4	40	40	100
1:1000	40	4	40	40	100
1:2000	40	5	40	40	100
1:3000	40	0	40	40	100
1:4000	40	0	39	39	97.5
1:5000	40	0	39	40	100
1:6000	40	0	40	40	100
1:7000	40	0	24	34	85
1:8000	40	0	16	20	50
Check	80	0	0	0	0

[1] Four replicated tests of 10 insects per test.

Table 3.—Laboratory tests of cevadine in dust suspensions to the adult grasshopper, *Melanoplus femur-rubrum* (DeGeer).

Dust Dilution	No. Insects[1]	Knock-down 1 Hr.	Mortality 24 hrs.	48 hrs.	Percentage Kill
1:1000	40	6	28	32	80
1:2000	40	0	15	22	55
1:3000	40	0	6	13	32.5
1:4000	40	0	8	10	25
1:5000	40	0	3	10	25
Check	40	0	0	3	7

[1] Four replicated tests of 10 insects per test.

The adult milkweed bugs employed in these tests were reared in the laboratory. The insects readily increased in numbers when confined in large crocks used as rearing cages. Within these crocks adult bugs deposited eggs on cotton from which new insect cultures could be established of known age. Only ten-day-old adults were tested, and following the dusting treatment the insects were removed to other wire screen cages and supplied with milkweed seed and water during a 72-hour observation period.

RESULTS.—The relative effectiveness of dust suspensions of the sabadilla constituents were determined by treating the insects with various levels of the toxicant in the dispersing agent. Preliminary trials indicated that the maximum level of toxicity of the sabadilla alkaloids was shown when the concentration was well under the

Table 4.—Toxicity of the principal alkaloids of sabadilla in kerosene to the milkweed bug.

Material	Concentration	No. Bugs[1]	Kill Knock-down 1 hr.	24 hrs.	48 hrs.	Per Cent Kill
Veratrine	1:1000	40	31	38	39	97
Veratrine	1:1500	40	12	10	11	27
Veratrine	1:2000	40	10	8	7	17
Check A		40	0	0	0	0
Veratridine	1:250	40	36	37	38	95
Veratridine	1:500	40	14	13	14	35
Veratridine	1:1000	40	12	4	2	5
Veratridine	1:2000	40	4	1	0	0
Check A		40	0	0	0	0
Cevadine	1:1000	40	32	36	39	97
Cevadine	1:1500	40	28	29	31	78
Cevadine	1:2000	40	22	21	22	55
Cevadine	1:3000	40	14	15	15	37
Cevadine	1:4000	40	2	1	1	2
Check A		40	0	0	0	0
DDT	1:100	40	0	0	0	0
DDT	1:33	40	0	2	2	5
DDT[2]	1:10	40	0	6	18	45
Check A		40	0	0	0	0
Check B		40	0	0	0	0

[1] Four tests of 10 bugs per test.
[2] Increases kill at 72 hr. period.
12% cyclohexanone employed in 1:10 DDT solution.
25% cyclohexanone employed in 1:250 and 1:500 veratridine solution and in check B.
Statistical analysis of previous tests with the milkweed bug showed that data obtained from 4 replicate tests of 10 bugs each is significant.

1 per cent level. Consequently, these dusts were first prepared and tested at concentrations of 1 part of constituent to 100 parts of diluent. Further dilutions were then made with the various toxicants until an expression of approximately 50 per cent mortality was obtained.

Against the milkweed bug (Table 1a) at concentrations of 1 part of constituent to 100 parts of inert, veratrine, cevadine, veratridine and the hydrochlorides gave 100 per cent kill in 48 hours. At this dilution cevine and the oil were non-toxic. At 1 part of constituent to 500 parts of inert (Table 1) only veratrine and cevadine remained highly toxic. Veratridine and the hydrochlorides were toxic at approximately the 50 per cent level at this concentration. Dilutions of 1 part of constituent to 1000 parts of inert (Table 1) showed that cevadine alone still showed high toxicity. Consequently, tests with dust preparations containing cevadine were repeated to determine the dilution level causing an approximate 50 per cent mortality (Table 2). The toxicity of cevadine at the 50 per cent level occurred at the dilution of one part of cevadine to 8000 parts of inert.

The above procedure was repeated against grasshoppers. Preliminary trials indicated that cevadine was the most effective constituent of sabadilla to grasshoppers, and dilutions of 1 part of this constituent to 1000–3000 parts of inert were tested. As indicated (Table 3) the 50 per cent level of toxicity of cevadine to the red-legged grasshopper was approximately 1 part of cevadine in 2000 to 3000 parts of inert. Figure 1 shows the relative toxicity of the various constituents of sabadilla in dust suspension against the milkweed bug and grasshopper.

Our previous work on the toxicity of kerosene solutions of the sabadilla alkaloids to the housefly showed that veratridine was much more toxic than cevadine (Ikawa, *et al.* 1945). In order to show that the higher toxicity of cevadine over veratridine in dust suspension against the milkweed bug was due to species specificity rather than to method of application of the insecticide, the relative effects of cevadine, veratridine, and veratrine in kerosene against the milkweed bug were determined (Table 4). In this form cevadine was also more toxic than veratridine. Cevadine gave 50 per cent mortality at a dilution of 1 to 2000 whereas the corresponding level for veratridine was 1 to 500. The 50 per cent mortality level for veratrine lies between 1 to 1000 and 1 to 1500 dilution. As is shown in table 4, DDT was ineffective until the concentration was increased to 1 to 10 and therefore is only slightly toxic to the milkweed bug. Figure 2 shows the relative toxicity of the various constituents of sabadilla in kerosene to the milkweed and a comparison with DDT.

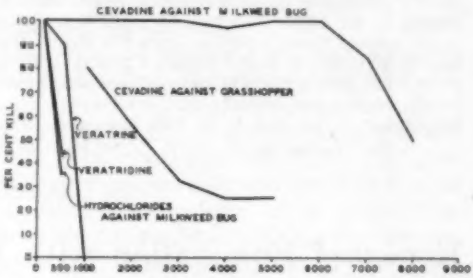


FIG. 1.—Concentration-Mortality curves of the sabadilla alkaloids in dust suspension against the milkweed bug and the red-legged grasshopper.

CONCLUSIONS.—1. The principal constituents of sabadilla seed were diluted at various levels with inert dusting material and their relative toxicities were tested against the milkweed bug and the red-legged grasshopper.

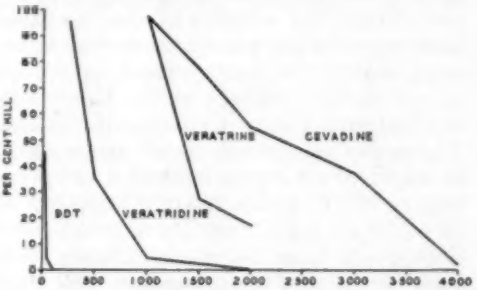


FIG. 2.—Concentration-mortality curves of the sabadilla alkaloids in kerosene against the milkweed bug and a comparison with DDT.

2. Cevadine was found to be the most toxic constituent to these insects while veratrine, veratridine and the hydrochlorides of veratrine possessed considerably less toxicity. Cevine and the oil obtained from petroleum ether extractions were non-toxic at levels employed.

3. Cevadine was toxic at the 50 per cent level of milkweed bugs in 1 part to

8000 parts of dispersing agent. Against the red-legged grasshopper, cevadine was toxic at the 50 per cent level in 1 part to approximately 2000 to 3000 parts of dispersing agent.

4. In kerosene solution against the milkweed bug cevadine is more toxic than veratridine. Cevadine at a dilution of 1 to 2000 gives 50 per cent mortality, whereas the corresponding dilution for veratridine is 1 to 500. The dilution of DDT in kerosene must be decreased to 1 to 10 before 50 per cent mortality is obtained under the conditions of these tests.—12-14-44.

LITERATURE CITED

Allen, T. C., R. J. Dicke, and J. W. Brooks. 1943. Rapid insecticide testing. Soap and Sanitary Chemicals. 19(4): 94–6. 121.

Allen, T. C., R. J. Dicke, and H. H. Harris. 1944. Sabadilla, *Schoenocaulon* spp., with reference to its toxicity to houseflies. JOUR. ECON. ENT. 37(3): 400–8.

Bussy, L. P. 1922. Proeven Met Stoffen, die aantrekkend, afstootend of schadelijk worken op de rupsen von *Prodenia litura* Fb. Bijdr. Dierkunde (Feest-Nummber) 21: 337–42.

Ikawa, Miyoshi, Robert J. Dicke, Thomas C. Allen and Karl Paul Link. 1945 Jour. Biol. Chem. (In press). The Principal alkaloids of sabadilla seed (*Schoenocaulon* sp.) and their toxicity in kerosene to *Musca domestica* L.

McAllister, L. C., and E. R. Van Leeuwen. 1930. Laboratory tests of miscellaneous chemials against the Codling Moth. JOUR. ECON. ENT. 23: 907.

Repeated Fumigation with HCN and the Development of Resistance in the California Red Scale[1]

D. L. LINDGREN[2] and R. C. DICKSON,[3] *University of California Citrus Experiment Station, Riverside*

In 1936, two strains or races of the California red scale, *Aonidiella aurantii* (Mask.), were obtained in the field. One of these races was known to be resistant, the other nonresistant, to fumigation with hydrocyanic acid gas (Quayle 1938; Lindgren 1938), but whether or not the races were pure was not known. Since that time, stock cultures of the two races have been reared in the insectary at the University of California Citrus Experiment Station. The scales are reared on banana squash, in insect proof rooms held at a temperature of 80° F. and a relative humidity of 50 to 60 per cent. Samples of scales have been taken from the stock cultures from time to time for fumigation and test purposes, but the stock cultures themselves have never been fumigated.

Under the laboratory conditions there are about 9 generations of scale a year. This means that from 1936 to 1944 the scale insects have passed through some 65 to 70 generations. Since the maximum number of generations a year under field conditions is 2.5 to 3, the 65 to 70 generations of scale in the laboratory are the equivalent of possibly 20 to 25 years of development under natural conditions.

Each year samples of adult scales have been taken from the unfumigated stock cultures for fumigation with HCN to determine whether the differential in kill between the two races remains constant, or whether in the absence of fumigation the resistant scale population becomes nonresistant. The fumigations were conducted in a 100-cubic-foot chamber at a temperature of 75° F. and an exposure of 40 minutes. The relative humidity varied from 50 to 70 per cent, this range in variation having no effect on the fumigation results. Each fumigation was replicated three times. The results of the fumigations, at 2-year intervals, are shown in table 1.

It may be observed from the data in table 1 that the differences in kill between the resistant and nonresistant races of red scale were maintained through the years from 1938 to 1944 in the absence of fumigation. This was to be expected, since Dickson (1941) and Yust *et al.* (1943) have shown that resistance in the red scale is inherited, and that the gene for resistance is sex-linked. This differential in kill between the two races continued in the absence of

[1] Paper No. 530, University of California Citrus Experiment Station, Riverside, California.
[2] Assistant Entomologist in the Experiment Station.
[3] Associate in the Experiment Station.

fumigation even though evidence given later in the present paper tends to show that the resistant scale population used was not pure resistant.

In 1939 and 1940, nine separate cultures of red scale were started in insect-proof cages, with the idea of repeatedly fumigating these scales with HCN to determine whether a resistant race could be produced from a nonresistant or semi-resistant population, or a more resistant race from the so-called resistant type. Seven of the cultures were obtained from the field by collecting large numbers of infested citrus fruits and transferring the young scale crawlers to banana squash. These field-collected scales varied from nonresistant to resistant in their reactions to HCN. The other two cultures, one of the nonresistant race and the other of the resistant race, were taken from the stock cultures that had been reared in the laboratory since 1936. All the test cultures were started from large numbers of scales, except that of the nonresistant race obtained from the stock population reared in the laboratory. This culture was started from a single male and female, on a small banana squash, the population being gradually built up. All the populations were reared in insect proof cages, and all possible precautions were taken to prevent contamination.

Table 1.—Effect of nonfumigation, over a period of years (1936–1944), on the differential in kill between nonresistant and resistant races of the California red scale, reared as stock cultures in the laboratory, as shown by the percentage kill obtained by HCN fumigation of test samples at 2-year intervals.[1]

HCN Concentration, Mg. Per Liter	Mean Per Cent Kill			
	1938	1940	1942	1944
	Non-resistant Scales			
0.19	95.0	95.6	97.3	96.6
0.36	97.5	98.7	99.4	98.9
0.54	96.3	99.7	100.0	99.4
0.70	100.0	99.9	99.8	100.0
0.90	—	100.0	99.9	99.7
1.00	100.0	100.0	99.9	99.4
	Resistant Scales			
0.19	50.2	47.0	43.6	46.5
0.36	67.4	63.3	62.6	60.3
0.54	81.0	80.9	81.3	74.9
0.70	84.0	91.3	87.3	81.8
0.90	89.4	93.9	91.5	90.0
1.00	96.2	92.0	93.5	94.0

[1] A total of 28,380 scales checked.

After the scale populations had increased sufficiently, the scale-infested squash were fumigated separately and returned to the cages to allow the survivors of the fumigation to reproduce. The concentrations of HCN used in these fumigations were 0.19 mg. per liter for the nonresistant scale and 0.36 and 0.70 mg. per liter for the resistant scale. It usually took about 2 to 3 generations to build the populations up to a point where they could again be fumigated.

At various intervals samples of scales were taken from the different populations, transferred to grapefruits, and fumigated to determine the mortality of scale at the various concentrations of HCN. The mortalities obtained after various numbers of repeated fumigations of a population were then compared with each other and with the initial mortality. These comparisons showed whether or not the scale populations were changing their reactions to HCN because of repeated fumigations.

RESULTS.—*Culture No. 1.* Originally nonresistant; started from a single male and female obtained from the stock culture reared in the laboratory since 1936. After nine fumigations (Table 2), with fumigation repeated about every second or third generation, the scales remained nonresistant, although there was a very slight change towards resistance at the lowest concentration.

Table 2.—Effect of repeated fumigation with HCN, over a period of years, on percentage kill of California red scale of Culture No. 1, originally nonresistant.[1]

HCN Concentration, Mg. Per Liter	Mean Per Cent Kill		
	Original Population	After 4 Fumigations	After 9 Fumigations
0.19	99.0	97.2	88.7
0.36	99.3	99.3	99.5
0.54	99.8	99.6	99.9
0.70	100.0	99.5	100.0
0.90	—	—	99.8
1.00	—	—	100.0

[1] A total of 8360 scales checked.

Culture No. 2. Originally nonresistant; obtained from a lemon grove. Preliminary fumigation indicated that these scales were similar to those of culture No. 1.

After nine fumigations they had become only slightly more difficult to kill, but still could be classified as nonresistant (Table 3). This indicates that the population

Table 3.—Effect of repeated fumigation with HCN, over a period of years, on percentage kill of California red scale of culture No. 2, originally nonresistant.[1]

HCN Concentration, Mg. per Liter	Mean Per Cent Kill		
	Original Population	After 6 Fumigations	After 9 Fumigations
0.19	98.7	91.1	81.7
0.36	100.0	99.4	96.0
0.54	100.0	99.9	99.8
0.70	—	99.9	100.0
0.90	—	100.0	100.0
1.00	—	100.0	100.0

[1] A total of 9250 scales checked.

obtained from the field was composed entirely or almost entirely of nonresistant scales.

Culture No. 3. Originally nonresistant; obtained from a lemon grove. After 12 fumigations the scales were more difficult to kill than originally. Classified as semiresistant.

Culture No. 4. Originally nonresistant, but some resistant scales probably present; obtained from a lemon grove. After five fumigations the population was resistant (Table 4). The repeated fumigations

Table 4.—Effect of repeated fumigation with HCN, over a period of years, on percentage kill of California red scale of culture No. 4, originally nonresistant, but with some resistant scales probably present.[1]

HCN Concentrations, Mg. per Liter	Mean Per Cent Kill	
	Original Population	After 5 Fumigations
0.19	94.5	37.7
0.36	97.9	65.7
0.54	99.6	76.4
0.70	99.8	79.8
0.90	99.6	91.7
1.00	—	93.8

[1] A total of 6870 scales checked.

doubtless selected out the resistant individuals. The data in table 4 show the scales to be as resistant as the resistant scales of table 1.

Culture No. 5. Originally nonresistant, but probably mixed; obtained from an orange grove. After six fumigations the scales were resistant to HCN.

Culture No. 6. Originally semiresistant; obtained from an orange grove. After five fumigations the scales were resistant to HCN.

Culture No. 7. Originally resistant; obtained from the stock culture of resistant scales reared in the insectary since 1936. After six fumigations (Table 5) the scales

Table 5.—Effect of repeated fumigation with HCN, over a period of years, on percentage kill of California red scale of culture No. 7, originally resistant.[1]

HCN Concentration, Mg. per Liter	Mean Per Cent Kill			
	Original Population	After 6 Fumigations	After 11 Fumigations	After 16 Fumigations
0.19	50.2	26.0	14.0	12.7
0.36	67.4	55.5	30.3	28.1
0.54	81.0	78.5	47.0	49.0
0.70	84.0	82.9	58.7	62.2
0.90	89.4	89.7	79.7	81.7
1.00	96.2	91.0	87.1	91.2

[1] A total of 14,285 scales checked.

were more difficult to kill than the original population, and resistance increased with 11 fumigations, but five additional fumigations (from 11 to 16) had little or no effect on resistance. This indicates that a given degree of resistance is reached and additional fumigations have no more effect.

Culture No. 8. Originally resistant; obtained from an infested orange grove. After 12 fumigations the scales became as resistant as those receiving 11 fumigations in culture 7. Six additional fumigations (Table 6) had little or no effect in increasing resistance.

Table 6.—Effect of repeated fumigation with HCN, over a period of years, on percentage of California red scale of culture No. 8, originally resistant.[1]

HCN Concentration, Mg. per Liter	Mean Per Cent Kill			
	Original Population	After 7 Fumigations	After 12 Fumigations	After 18 Fumigations
0.19	56.0	26.3	14.6	10.7
0.36	65.1	38.8	36.9	25.5
0.54	80.7	58.6	40.4	48.0
0.70	89.6	80.8	71.2	76.0
0.90	91.0	97.0	81.6	79.0
1.00	—	—	87.4	88.7

[1] A total of 14,160 scales checked.

Culture No. 9. Originally resistant; obtained from an infested lemon grove. The results obtained from the repeated fumigations were similar to those obtained in cultures 7 and 8. After 12 fumigations the scales were more resistant to HCN than the original culture, but four additional fumigations had little or no effect in increasing resistance.

DISCUSSION.—Two red-scale populations, one resistant and the other nonresistant, were obtained from the field and held without fumigation for some 70 generations to see whether the resistant population would revert to the nonresistant state that is thought to have been general at the time fumigation was begun in California. Under laboratory conditions the same differential in resistance between the two races of red scale was maintained through 65 to 70 generations, even though the stock culture of scale received no fumigations during this time (Table 1). This differential was maintained although the resistant scales were evidently not a pure resistant race, since repeated fumigations increased resistance (Table 5, culture No. 7).

It seems probable that resistance in any scale-infested grove has been brought about by selecting out the resistant scale by fumigation. But even those groves that have a record of being very resistant are not so resistant as they may eventually become (Tables 5 and 6; cultures Nos. 7, 8, and 9).

Yust *et al.* (1943), found that repeated fumigations increased the resistance of the resistant scale, and concluded: "In view of the high mortality of the nonresistant strain in these tests, it is difficult to attribute increased resistance entirely to the elimination of nonresistant individuals in the original stocks." This has also been apparent in the present study, since in the repeated fumigations on the resistant cultures, the concentration of HCN was approximately 2 to 4 times as great as that used on the nonresistant red scale (0.19 mg./liter on the nonresistant scale as against 0.36 and 0.70 mg./liter on the resistant).

A partial explanation of the slowness in the practical elimination of genes for nonresistance may be found in the mechanism of inheritance. While the males are either entirely resistant or entirely nonresistant, it seems unlikely that many of them survived. The females, on the other hand, may be resistant, nonresistant, or semiresistant. These semiresistant females are heterozygous, carrying genes both for resistance and for nonresistance, and are midway between the two races in their ability to survive HCN fumigation. In a scale population predominantly resistant, very few females homozygous for nonresistance will be found, nearly all the genes for nonresistance being carried by individuals that also carry genes for resistance. Therefore, in the development of a purely resistant race it is not the nonresistant individuals that must be eliminated so much as the semiresistant ones, which are relatively hard to kill by HCN fumigation. The more nearly the population becomes one of purely resistant scales the greater is the likelihood that the genes for nonresistance present will be contained in semiresistant females, and hence the slower the population change.—1-15-45.

LITERATURE CITED

Dickson, R. C. 1941. Inheritance of resistance to hydrocyanic acid fumigation in the California red scale. Hilgardia **13**(9): 515–22.

Lindgren, D. L. 1938. The stupefaction of red scale, *Aonidiella aurantii*, by hydrocyanic acid. Hilgardia **11**(5): 213–25.

Quayle, H. J. 1938. The development of resistance to hydrocyanic acid in certain scale insects. Hilgardia **11**(5): 183–210.

Yust, H. R., H. D. Nelson and R. L. Busbey. 1943. The influence of repeated fumigation with HCN on the susceptibility of the California red scale. JOUR. ECON. ENT. **36**(6): 872–4.

Effect of Reduced Amounts of Calcium Arsenate on Boll Weevil Control and Cotton Yield

R. C. Gaines, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

The experiments with reduced amounts of calcium arsenate for boll weevil control that have been conducted in field plots and cages at Tallulah, La., during the years 1933 to 1942 are summarized in this paper. The reduction in dosage in most cases was accomplished by mixing calcium arsenate with such diluents as lime, sulfur, or clay, none of which have any great effect on boll weevils.

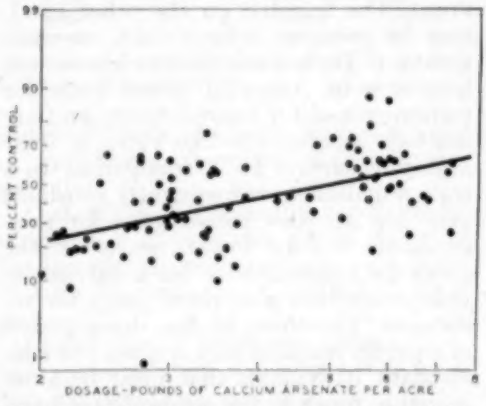


Fig. 1.—Relation between amount of calcium arsenate applied per acre and percentage of boll weevil control.

Percentage control, dosage, yield, and the date on which treatments were started, are presented in table 1. The plots in experiments 1 to 10, inclusive, 12, 13, 14, and 16 to 24, inclusive, were approximately 1 acre in size and were arranged in series with 1 replicate in each experiment. The plots in experiments 11 and 15 were 0.25 acre in size and were arranged in 4-by-4 and 6-by-6 latin squares, respectively. The plots in experiments 25, 26, 27, and 28 were 0.25 acre or larger in size and were arranged in randomized blocks with 4, 6, 4, and 4 replicates, respectively.

Percentage control for each treatment was computed by the formula $(X-Y)100/X$, with X the average percentage of squares found to be punctured by the boll weevil in the checks and Y the average percentage punctured in the treated plots. Only the records made after treatment applications were started were included in the averages. For constructing figure 1 the dosages (pounds of calcium arsenate per acre) were transformed to logarithms and percentages to probits by available tables (Bliss 1935). The dosage-control curve was obtained from equations computed by the method of least squares. The estimated boll weevil control for a dosage of 8 pounds of calcium arsenate per acre was 65 per cent; for 7 pounds, 61 per cent; for 6 pounds, 56 per cent; for 5 pounds, 50 per cent; for 4 pounds, 43 per cent; for 3 pounds, 34 per cent; and for 2 pounds, 23 per cent. The effect of dosage on percentage control was significant.

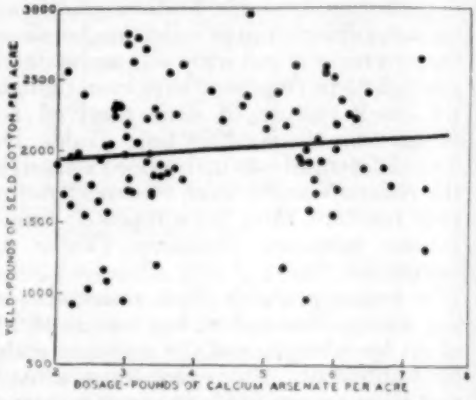


Fig. 2.—Relation between Cotton yield and amount of calcium arsenate applied per acre.

The dosage-yield curve plotted in figure 2 was also obtained from an equation computed by the method of least squares. The estimated yield for a dosage of 8 pounds of calcium arsenate per acre was 2129 pounds of seed cotton per acre; for 7 pounds, 2098 pounds; for 6 pounds, 2067 pounds; for 5 pounds, 2036 pounds; for 4 pounds, 2005 pounds; for 3 pounds, 1974 pounds; for 2 pounds, 1943 pounds; and for no treatment, 1815 pounds. The effect of dosage on yield was not significant.

[1] The field-plot experiments in control were conducted by M. T. Young, G. L. Garrison, and assistants; the cage tests, by G. L. Smith, A. L. Scales, and assistants.

Table 1.—Records obtained in field-plot experiments in which reduced amounts of calcium arsenate were applied for control of the boll weevil, Tallulah, La., 1933 to 1943.

Year	Treatment	Treatment Applications		Pounds of Calcium Arsenate Per Acre Per Application	Per Cent Control	Cotton Yield in Pounds Per Acre
		Number	Date started	Alone or in Mixture		
	Check					811
1933	Calcium arsenate	6	July 8	7.3	61.2	1307
	Calcium arsenate and lime 1:1	6	8	3.4	57.6	1197
	Calcium arsenate and lime 1:2	6	8	2.5	65.1	1031
	Check					1132
1934	Calcium arsenate	10	June 28	6.0	86.6	1548
	Calcium arsenate and lime 1:1	10	28	3.4	75.2	1711
	Calcium arsenate and lime 1:2	10	28	2.4	50.3	1548
	Check					1407
1934	Calcium arsenate	9	June 30	6.0	63.0	2008
	Calcium arsenate and lime 1:1	9	30	3.3	24.7	1979
	Calcium arsenate and lime 1:2	9	30	2.3	18.9	1813
	Check					887
1934	Calcium arsenate	5	July 7	5.6	87.8	957
	Calcium arsenate and lime 1:1	5	7	3.0	31.5	944
	Calcium arsenate and lime 1:2	5	7	2.2	19.3	926
	Check					1253
1935	Calcium arsenate	6	July 3	5.3	69.0	1181
	Calcium arsenate and lime 1:1	6	3	2.7	40.6	1167
	Check					1212
1935	Calcium arsenate	6	July 13	5.7	52.8	1700
	Calcium arsenate and lime 1:1	6	13	2.7	64.4	1084
	Check					1327
1935	Calcium arsenate	6	June 28	5.6	78.1	1581
	Calcium arsenate and lime 1:1	6	28	2.7	61.9	1569
	Check					2381
1936	Calcium arsenate	5	July 25	5.8	61.4	2587
	Calcium arsenate and lime 1:1	5	25	3.0	42.0	2746
	Calcium arsenate and sulfur 1:1	5	25	3.1	31.9	2624
	Check					2304
1936	Calcium arsenate	5	July 25	5.4	67.3	2599
	Calcium arsenate and lime 1:1	5	25	3.2	57.3	2793
	Calcium arsenate and sulfur 1:1	5	25	3.0	53.2	2820
	Check					2123
1936	Calcium arsenate	4	July 29	5.3	60.5	2245
	Calcium arsenate and lime 1:1	4	29	2.8	26.8	2294
	Calcium arsenate and sulfur 1:1	4	29	2.9	65.0	2319
	Check					2380
1936	Calcium arsenate	8	July 28	7.2	56.5	2640
	Calcium arsenate and lime 1:1	8	28	3.6	37.8	2544
	Calcium arsenate and sulfur 1:1	8	28	3.8	42.4	2602
	Check					2783
1937	Calcium arsenate	5	July 24	4.8	69.8	2954
	Calcium arsenate and lime 1:1	5	24	2.1	26.0	2558
	Calcium arsenate and sulfur 1:1	5	24	3.3	41.1	2712

Table 1.—*continued*

Year	Treatment	Treatment Applications: Number	Treatment Applications: Date started	Pounds of Calcium Arsenate Per Acre Per Application Alone or in Mixture	Per Cent Control	Cotton Yield in Pounds Per Acre
	Check					2088
1937	Calcium arsenate	6	July 12	5.0	72.8	2157
	Calcium arsenate and lime 1:1	6	12	2.4	20.3	2395
	Calcium arsenate and sulfur 1:1	6	12	3.3	60.3	2225
	Check					1954
1937	Calcium arsenate	6	July 12	4.7	42.6	2319
	Calcium arsenate and lime 1:1	6	12	2.3	23.0	1984
	Calcium arsenate and sulfur 1:1	6	12	2.6	27.3	1938
	Check					2258
1937	Calcium arsenate	7	July 19	6.2	50.0	2253
	Calcium arsenate and lime 1:1	7	19	3.7	29.6	2254
	Calcium arsenate and sulfur 1:1	7	19	4.7	35.5	2385
	Calcium arsenate and sulfur 1:2	7	19	5.2	32.2	2407
	Calcium arsenate and sulfur 1:4	7	19	2.8	15.1	2241
	Check					1857
1937	Calcium arsenate	5	July 15	6.7	43.7	1881
	Calcium arsenate and sulfur 1:2	5	15	5.5	54.0	1953
	Calcium arsenate and sulfur 1:4	5	15	3.6	19.5	1846
	Check					1842
1937	Calcium arsenate	5	July 15	5.6	41.8	1921
	Calcium arsenate and sulfur 1:2	5	15	5.3	72.9	2180
	Calcium arsenate and sulfur 1:4	5	15	3.0	62.3	2189
	Check					2391
1937	Calcium arsenate	5	July 15	6.5	40.5	2407
	Calcium arsenate and sulfur 1:2	5	15	5.4	58.3	2277
	Calcium arsenate and sulfur 1:4	5	15	3.5	55.8	2245
	Check					1339
1938	Calcium arsenate	8	July 26	6.0	48.4	1731
	Calcium arsenate	8	26	3.4	24.2	1685
	Calcium arsenate and sulfur 1:1	8	26	3.0	33.6	1803
	Check					2269
1938	Calcium arsenate	6	July 14	6.0	47.4	2517
	Calcium arsenate	6	14	3.4	54.6	2295
	Calcium arsenate and sulfur 1:1	6	14	2.9	49.6	2308
	Check					2015
1938	Calcium arsenate	5	July 26	6.0	61.2	2184
	Calcium arsenate	5	26	3.0	28.3	2098
	Calcium arsenate and sulfur 1:1	5	26	2.8	.8	2048
	Check					2269
1938	Calcium arsenate	6	July 14	5.8	69.8	2543
	Calcium arsenate and sulfur 1:1	6	14	6.1	62.3	2353
	Calcium arsenate and sulfur 1:2	6	14	4.2	40.9	2421
	Calcium arsenate and sulfur 1:1	6	14	2.8	40.9	2324
	Check					1963
1938	Calcium arsenate	7	July 14	5.6	62.0	2005
	Calcium arsenate and sulfur 1:1	7	14	6.3	65.6	2226
	Calcium arsenate and sulfur 1:2	7	14	4.4	43.4	2216
	Calcium arsenate and sulfur 1:1	7	14	3.2	31.8	2057

Table 1.—*continued*

Year	Treatment	Treatment Applications		Pounds of Calcium Arsenate Per Acre per Application Alone or in Mixture	Per Cent Control	Cotton Yield in Pounds Per Acre
		Number	Date started			
	Check					1601
1938	Calcium arsenate	7	July 14	5.5	48.5	1921
	Calcium arsenate and sulfur 1:1	7	14	5.8	62.4	1926
	Calcium arsenate and sulfur 1:2	7	14	3.8	58.5	1799
	Calcium arsenate and sulfur 1:1	7	14	3.0	46.2	1718
	Check					1993
1939	Calcium arsenate	4	July 13	5.7	54.0	2080
	Calcium arsenate	4	13	2.7	28.1	2035
	Calcium arsenate and sulfur 1:1	4	13	3.0	38.0	1973
	Check					1490
1942	Calcium arsenate	4	July 30	5.7	18.6	1800
	Calcium arsenate and sulfur 1:2	4	30	2.6	16.4	1645
	Calcium arsenate, sulfur, etc.	4	30	2.5	21.1	1760
	Calcium arsenate, sulfur, etc.	4	30	2.1	24.7	1695
	Calcium arsenate, sulfur, etc.	4	30	2.2	8.3	1620
	Check					1635
1942	Calcium arsenate	6	July 21	7.3	25.7	1736
	Calcium arsenate and sulfur 1:1	6	21	3.5	9.6	1823
	Calcium arsenate, sulfur, etc.	6	21	3.5	16.1	1901
	Calcium arsenate, sulfur, etc.	6	21	3.4	27.2	1830
	Calcium arsenate, sulfur, etc.	6	21	3.1	16.7	1710
	Check					1857
1943	Calcium arsenate	4	July 9	6.8	41.5	1756
	Calcium arsenate, etc.	4	9	6.4	25.0	1876
	Calcium arsenate, sulfur, etc.	4	9	3.3	18.0	1922
	Calcium arsenate, sulfur, etc.	4	9	2.0	11.5	1905
	Calcium arsenate and sulfur	4	9	3.7	13.6	1872
	Calcium arsenate and sulfur	4	9	2.2	18.3	1961

Table 2.—Boll weevil net mortalities in cage tests from various amounts of calcium arsenate, Tallulah, La., 1933 to 1942.

Year	Treatment	Per Cent Control
1933	Calcium arsenate	75
	Calcium arsenate and lime 1:1	45
	Calcium arsenate and lime 1:2	31
1934	Calcium arsenate	79
	Calcium arsenate and lime 1:1	55
	Calcium arsenate and lime 1:2	49
	Lime	1
1935	Calcium arsenate	60
	Calcium arsenate and lime 1:1	32
	Calcium arsenate and lime 1:3	0
	Calcium arsenate and lime 1:9	0
	Calcium arsenate and sulfur 1:1	41
	Calcium arsenate and sulfur 1:3	25
	Calcium arsenate and sulfur 1:9	25
	Calcium arsenate and clay 1:1	31
	Calcium arsenate and clay 1:3	4
	Calcium arsenate and clay 1:9	0

Table 2.—*continued*

Year	Treatment	Per Cent Control
1936	Calcium arsenate	79
	Calcium arsenate and lime 1:1	56
	Calcium arsenate and lime 1:2	35
	Calcium arsenate and lime 1:4	38
	Calcium arsenate and sulfur 1:1	53
	Calcium arsenate and sulfur 1:2	56
	Calcium arsenate and sulfur 1:4	44
	Calcium arsenate and clay 1:1	47
	Calcium arsenate and clay 1:2	27
	Calcium arsenate and clay 1:4	19
1937	Calcium arsenate	43
	Calcium arsenate and lime 1:1	39
	Calcium arsenate and lime 1:2	34
	Calcium arsenate and lime 1:4	47
1937	Calcium arsenate	56
	Calcium arsenate and sulfur 1:1	43
	Calcium arsenate and sulfur 1:2	41
	Calcium arsenate and sulfur 1:4	38
1937	Calcium arsenate	43
	Calcium arsenate and clay 1:1	56
	Calcium arsenate and clay 1:2	47
	Calcium arsenate and clay 1:4	36
1938	Calcium arsenate	70
	Calcium arsenate and sulfur 1:1	63
	Calcium arsenate and sulfur 1:2	59
1938	Calcium arsenate	82
	Calcium arsenate and lime 1:1	49
	Calcium arsenate and sulfur 1:1	72
	Calcium arsenate and calcium carbonate 1:1	74
1939	Calcium arsenate	60
	Calcium arsenate and lime 1:1	49
	Calcium arsenate and lime 1:2	48
	Calcium arsenate and sulfur 1:1	58
	Calcium arsenate and sulfur 1:2	59
	Calcium arsenate and calcium carbonate 1:1	70
	Calcium arsenate and calcium carbonate 1:2	50
1942	Calcium arsenate	64
	Calcium arsenate and sulfur 1:1	53
	Calcium arsenate and sulfur 1:2	41
	Calcium arsenate and sulfur 1:3	38
	Calcium arsenate and sulfur 1:5	26
	Calcium arsenate and sulfur 1:7	39

Records were also obtained in cage tests with similar mixtures. No record was made of dosage, but an attempt was made to apply equal amounts of calcium arsenate alone and of mixtures of calcium arsenate and some diluent, thereby reducing the amount of calcium arsenate. These records are presented in table 2. The relation between amount of calcium arsenate applied and net boll weevil mortality is apparent.

SUMMARY.—In field-plot experiments conducted at Tallulah, La., from 1933 to 1943 the amount of calcium arsenate applied either alone or in a mixture was greatly reduced from the average application of about 6 pounds per acre. Dosage significantly affected percentage of boll weevil control but the effect on yield was not significant. Reductions in the amounts of calcium arsenate applied in cage tests were followed by reductions in the mortalities of boll weevils.

LITERATURE CITED

Bliss, C. I. 1935. The calculation of the dosage-mortality curve. Appendix by R. A. Fisher. Ann. Appl. Biol. **22**: 134–67.

Dr. Reginald H. Painter, Department of Entomology, Kansas State College, was one of the Agricultural Experiment Station workers appointed a member of the regional "Committee on Future Plans for the Improvement of Hard Red Winter Wheat in the Great Plains." Other members of this committee from the nine Great Plains States are from the fields of agronomy, plant breeding, botany, plant pathology, milling industry and chemistry.

Mr. Noel L. H. Krauss of the Board of Agriculture and Forestry, Territory of Hawaii, is spending a month or two at Manhattan, Kansas, collecting *Apanteles bedelliae* Ash. for introduction into Hawaii. This parasite in the United States attacks the bindweed leafminer, *Bedellia somnulentella* (Zell.). It is being tested as a possible control in Hawaii for the sweet potato leaf miner, *Bedellia archidella* Wlsm., a closely related Lyonetiid.

Insecticidal Properties of Miscellaneous Plants

ROY HANSBERRY and ROBERT T. CLAUSEN

The critical shortages of vegetable insecticides, occasioned by the war, aroused and revived the interest of entomologists in plants of the western hemisphere which might be of use in the control of insects. Plants examined at Cornell University were from four sources: (1) Brazilian fish-poison plants sent through the cooperation of the Instituto Agronomico do Norte, Belém; (2) legumes and other plants of New York State, collected by R. T. Clausen; (3) insecticidal, fish-poison or medicinal plants of Mexico and Central America, collected by R. T. Clausen; and (4) miscellaneous plants sent in by various collectors.

Much of the work on this project has been concerned with the seeds of the yam bean, detailed studies of the chemistry, botany and toxicity having been published or now in press (Norton 1943; Clausen, 1944; Hansberry *et al.* 1945). For that reason, reports on the toxicity of the seeds of the yam bean are, with one exception, omitted from this paper.

In making insecticidal tests of plant material of unknown toxicity, the plant tissue was thoroughly dried and ground in a laboratory Raymond mill. This plant dust was blown up into a dusting tower and allowed to settle on leaves and insects. Specimen dishes (5×11 cm.) bottoms of which had been lined with wet paper towelling were used to hold the leaves upon which the test insects were placed. With this method, a heavy dust of the undiluted plant material was applied to the insects, their food, and all surfaces over which they crawled. If any toxicity to the test species existed, this method should demonstrate it. Mortality counts were made daily for 4 days. If the foliage had been completely consumed and no mortality had occurred, the experiment was discontinued after 2 days. In some cases, especially where initial tests with the Mexican bean beetle showed some toxicity, different techniques or insects were used in additional tests,

BRAZILIAN FISH-POISON PLANTS.—The following plants were tested as described above, and showed no toxicity[1] to larvae of bean beetles.

Wallacea insignis Spruce	bark	Amazonas
Antonia ovata Pohl var. *pilosa* Progel	wood	Minas Gerais
Ichthyothere rufa Gardn.	entire plant	Minas Gerais
Petivera alliacea L.	leaves, stems, roots	
Clibadium sp.	stems and leaves	

Wallacea insignis, *Antonia ovata* var. *pilosa* and *Petivera alliacea* were also tested against larvae of silkworms in the same way and showed low toxicity.

Two samples of seeds of *Pachyrrhizus tuberosus* from Minas Geraes, a red- and a black-seeded variety, both showed toxicity to larvae of the bean beetle about equal to typical *Pachyrrhizus erosus* from Mexico (Hansberry *et al.* 1945).

Two composite samples of roots, one of *Lonchocarpus utilis* A. C. Smith and one of *L. urucu* Killip & Sm., were sent from the institute garden of mother plants at Belém. These two species comprise most of the cube and timbo of commerce. Chemical analysis of the ground roots on arrival in Ithaca, showed *L. utilis* to contain 5.6 per cent rotenone and 16.7 per cent ether extract; and *L. urucu* 4.9 per cent rotenone and 13.9 per cent ether extract. Tests with dusts made up to contain 0.5 per cent rotenone yielded the following kills of third instar Mexican bean beetle larvae, 150 insects in each test: *Lonchocarpus utilis*, 93 in 1 day, 134 in 2 days, 141 in 3 days and 145 in 4 days; *L. urucu*, 81 in 1 day, 115 in 2 days, 134 in 3 days and 144 in 4 days. Although these differences are not large, they were consistent throughout the six replicates of the experiment and lead to the conclusion that *L. utilis* not only has a higher content of rotenone and resin than *L. urucu*, but also has a higher toxicity to bean beetle larvae per unit of rotenone. Dr. F. C. Camargo, director of the Instituto Agronomico do Norte, advises, however, that *L. urucu* consistently gives a higher yield of root and is, therefore, the preferred species for cultivation.

[1] In this paper, "no toxicity" means less than 10 per cent dead and all foliage eaten in 48 hours. "Moderate toxicity" means from 10 to 50 per cent mortality in 96 hours. Higher kills will be dealt with specifically.

PLANTS OF NEW YORK.—If a list of miscellaneous insecticidal plants is studied, it will be found that the proportion of plants of insecticidal interest in the legume family is greater than that in any other family. It would seem of some interest, then, to examine systematically all the legumes growing in any area. Such an attempt has been made for the legumes of New York. Not all of the species in the New York flora have been collected and examined, but most have been studied or are being studied. A few introduced species are included in the list below, also a few collected in other states. Further, a number of non-leguminous plants of New York have been collected and tested. They were studied because they are known either to contain insecticidal alkaloids or to be related to species of insecticidal interest. Unless otherwise mentioned, the entire plant was used. Numbers after names refer to specimens in the herbarium of the Department of Botany at Cornell University.

LEGUMINOSAE

Amorpha fruticosa L., mature pods with seeds, C5960.
Amphicarpa comosa (L.) G. Don C5929, C5953.
Anthyllis vulneraria L., C5600.
Apios americana Med., C5815.
Astragalus Blakei Eggleston, C5914.
Astragalus canadensis L., C5902.
Astragalus neglectus (T. & G.) Sheldon, C6319.
Baptisia tinctoria (L.) R. Br., C5941.
Cassia hebecarpa Fernald (*C. marilandica* L.), C5852a.
Cassia nictitans L., C5933.
Cercis canadensis L., C42–35.
Coronilla varia L., C5872.
Crotolaria sagittalis L., C5934.
Desmodium canadense (L.) DC., C5873.
Desmodium Dillenii Darl., C5937.
Desmodium glutinosum (Muhl. ex Willd.) Wood, C6320.
Desmodium paniculatum (L.) DC., C559.
Gleditsia triacanthos L. leaves and stems, seeds and pods, C5951.
Gymnocladus dioica (L.) Koch, seeds and pods, C5954a.
Hedysarum boreale Nutt., C5913.
Lathyrus latifolius L., C5841.
Lathyrus maritimus (L.) Bigel, C6304.
Lathyrus ochroleucus Hook., C5845.
Lathyrus palustris L., C5852.
Lespedeza capitata Michx., C5906, C5955.
Lespedeza hirta (L.) Hornem., C5956.
Lespedeza intermedia (Wats.) Britton, C5900
Lespedeza virginica (L.) Britton, C5939.
Latus corniculatus L., C5839.
Lupinus perennis L.
Medicago lupulina L.
Medicago sativa L. C5814
Melilotus alba Desr., C5857
Melilotus altissima Thuill., C6002.
Melilotus officinalis (L.) Lam., C6337.
Robina hispida L., leaves and stems, C5958a.
Robina pseudacacia L., leaves, seeds, pods, C5949.
Robina viscosa Vent., leaves and stems, C6322.
Tephrosia virginiana, (L.) Pers., roots, leaves and stems, C5946 and Coffin 12 and 12a.
Thermopsis mollis (Michx.) M. A. Curtis, C5977.
Trifolium agrarium L., C5961.
Trifolium arvense L., C5907.
Trifolium dubium Sibth., C6010.
Trifolium hybridum L., C5809.
Trifolium procumbens L., C6333.
Trifolium pratense L., C5928.
Trifolium repens L., C5950.
Vicia americana Muhl., C5884.
Vicia Cracca L., C5856.
Vicia dasycarpa Ten., C5997.
Vicia tetrasperma (L.) Moench, C5992.
Vicia villosa Roth., C5996.

MISCELLANEOUS SPECIES

Achillea millefolium L. C5870.
Anthemis arvensis L., C5787.
Anthemis Cotula L., C5816a.
Barbarea vulgaris R. Br., C6283.
Carex torta Boott., C6284.
Delphinium sp. (ornamental hybrids), leaves, stems, seeds.
Equisetum arvense L., C6276.
Lycopodium complanatum L. var. *flabelliforme* Fernald, C6308.
Lycopodium obscurum L., C6343.
Lythrum Salicaria L., C5869.
Pteridium aquilinium (L.) Kuhn var. *latiusculum* (Desv.) Und. (*P. latiusculum* Desv.), C5880.
Rhododendron maximum L., C5965.
Tanacetum vulgare L., C5840a.
Veratrum viride Ait., C6299.
Xenthium orientale L., young seedlings, C5952.

With the exception of the seeds of *Amorpha fruticosa* and roots of *Tephrosia virginiana*, which showed moderate toxicity, no New York plants were toxic.

PLANTS OF MEXICO AND CENTRAL AMERICA.—While collecting samples of yam beans in Mexico and Central America, R. T. Clausen had opportunity to collect a number of samples of plants reputed by the natives, or previously reported in scientific literature, to have insecticidal value. The numbers after names refer to collections filed in the herbarium of the Department of Botany at Cornell University, where additional data can be obtained. Thanks are due Dr. Leon Croizat for identification of the *Dalembertia* and Dr. S. F. Blake for the *Schkuhria*.

Caesalpinia pulcherrima (L.) Sw., C6035.
Dalea citriodora (Cav.) Willd., leaves and stems, C6191.
Dalembertia populifolio Baill., C6052.
Gliricidia sepium (Jacq.) Steud., C6053 and C6170.
Haemotoxylon brasilleto Karst., leaves and stems, C6051.
Haplophyton cimicidum A. D.C., roots, leaves and stems, C6178.
Hymenocallis ?, C6058.

Indigofera suffruticosa Mill., C6162 and C43–102.
Lonchocarpus leucanthus Burkart, C6168.
Lonchocarpus minimiflorus Donn. Smith, C6165.
Mandeville foliosa Hemsl., C6057.
Myrica rufidula Schlecht., C6221.
Philodendron ?, C6056.
Satureja laevigata Standl., C6090.
Schkuhria (*Tetracarpum flavum* Rydb.), C6091.
Senecio, C6060.
Tephrosia Talpa S. Wats., roots, leaves and stems, C6059.
Tephrosia Talpa S. Wats., roots, leaves and stems, C6101.
Tephrosia toxicaria (Sw.) Pers., roots, leaves and stems, C6215.
Tephrosia ? toxicaria (Sw.) Pers., C6194.
Thevetia thevetioides (H.B.K.) K. Schum., seeds, C6054.

The roots of the *Tephrosia* species were moderately toxic, but even *Tephrosia toxicaria*, which is reputed to be highly toxic, killed less than half of the larvae of the Mexican bean beetle in 4 days. Although several of the other species were in use in Mexico for killing insects, none of these showed even moderate toxicity to larvae of the bean beetle.

MISCELLANEOUS PLANTS.—Two species sent in by Leo Norodny, Roseau, Dominica, B. W. I., were highly toxic to silkworm larvae. These were *Clibadium surinamense* L. (*C. sylvestre* Baill.) and *Pithecellobium trapezifolium* Benth. (*P. jupanba* Urb.). The former is an herbaceous plant, the aerial parts of which were used in the tests. *Pithecellobium* is a tree, the leaves only being tested. Both species gave complete kills of silkworm larvae in 3 days, although neither was effective against larvae of the Mexican bean beetle, potato aphids, or bean aphids.

A returned missionary sent in seeds and leaves of a fish poison plant called "dyaba" by the natives of French Guiana where the plant was collected. The plant was identified from seedlings grown in the greenhouse as *Tephrosia Vogelii* Hook. f. The leaves were found to contain 1 per cent rotenone and 7.6 per cent total ether extractives. A dust containing half ground leaves and half talc was as toxic to larvae of the Mexican bean beetle as 0.5 per cent rotenone dust prepared from cube root. Seedlings grew in one year to 6 feet in tubs in the greenhouse. Because of the rapid growth, the potential yield of rotenone-bearing tissue of this species may be high enough to be promising. Seeds have been sent for trial to the U. S. Agricultural Experiment Station at Mayaguez, Puerto Rico, and to the Instituto Agronomico do Norte at Belém, Brazil.

Because of the potent pharmacological effect of the seeds of *Abrus* and *Erythrina*, they also were tested, but the ground seeds of *Abrus precatorius* L. from Florida and *Erythrina rubrinervia* H. B. & K. from Guatemala showed no toxicity to larvae of the Mexican bean beetle.

Ground, dried pennyroyal plants (*Pycnothymus rigidus* [Bart.] Small) were being exploited on a small scale as repellents for vegetable insects in the vicinity of Ochopee, Florida, during the winter of 1943–44. Neither the commercial material, nor freshly ground plants, either prevented the larvae of the bean beetle or aphids from feeding or caused any mortality in the laboratory tests.

Sap from *Hyra polyandra* Baill. from Mexico gave moderate kills of *Aphis rumicis* when diluted 1–10 and used as a contact spray. This is extremely caustic and irritating to human skin, eyes and respiratory passages. The sample used had fermented before tests were made. A plant sent in from Mexico as *Haplophyton cimicidum* was identified as *Maurandya antirrhiniflora* H. & B. It was ineffective against larvae of the bean beetle and of the Colorado potato beetle, but killed 86 per cent of the silkworms in 4 days.

Two samples of leguminous seeds, one called "*tapiramo*" from Venezuela and one called "*lenteja boccona*" from Peru were apparently the same or closely related species which have not yet been identified botanically. Neither was effective against the bean beetle.

Large apocynaceous seeds of unknown origin, claimed to have insecticidal properties, apparently were "ordeal beans" from Madagascar (*Cerbera taughin* Hook). They were not toxic to larvae of the bean beetle.—12-2-44.

LITERATURE CITED

Clausen, R. T. 1944. A botanical study of the yam beans (*Pachyrrhizus*) Cornell University Agricultural Experiment Station. Memoir no. **264**.

Hansberry, Roy, L. B. Norton and R. T. Clausen. 1945. Report on the toxicity and chemistry of the yam beans (*Pachyrrhizus*). In press.

Norton, L. B. 1943. Rotenone in the yam bean (*Pachyrrhizus erosus*). Jour. Am. Chem. Soc. **65**: 2259.

Evaluating the Effectiveness of Sprays Against the Japanese Beetle: A Laboratory Method

W. E. Fleming, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In the search for new and better sprays it is not practical to conduct the preliminary tests with untried materials in commercial orchards and in other private plantings on the scale required to demonstrate their merits. It is desirable that all such preliminary tests with a spray material be made in the laboratory, the aim being to obtain information on the minimum concentration that might be required, to develop suitable stickers and spreaders, and to determine the resistance of the spray deposits to weathering and the reaction of plants to the material. The purpose of the present paper is to describe the method now used by the Bureau of Entomology and Plant Quarantine for the preliminary evaluation of sprays for use against the Japanese beetle, *Popillia japonica* Newm., in the belief that it will be of value to other investigators in this field.

Laboratory Methods Used Prior to 1943.—The method by which several Japanese beetles were confined in a cage with sprayed plants has been used for over 20 years. About 10 years ago the writer (Fleming 1934) developed a more satisfactory cage in which the temperature, relative humidity, and light were controlled, the quality and quantity of the evaluations being thereby improved and increased. This procedure is of value in measuring the gross effectiveness of a spray as a stomach poison, but since beetles thus caged are forced to feed on the sprayed plants or starve, it does not give a fair indication of the potential repellent value of the spray, repellency usually being the most important factor in the control of the beetles in the field. It was found that the introduction of an unsprayed plant with the sprayed plant in a cage did not correct the situation, because in the restricted environment the beetles were not discriminative but were erratic in choosing between the sprayed and unsprayed plants.

Improvements in Methods.—In 1940 a preliminary test was made of the repellency of a few sprays by arranging sprayed and unsprayed plants in tubs in a latin square in an open field near a heavily infested vineyard. The results were so encouraging that the method was tried more extensively during 1941 and 1942. Of all the experimental designs the latin square offers the greatest possibility of accuracy in that it corrects in two directions the effect of variations in the density of the population of beetles throughout the block. Since the number of replications is equal to the number of treatments, this design is much less flexible than randomized blocks, and latin squares larger than 10 by 10 are seldom used.

The method of arranging sprayed and unsprayed plants in tubs in the presence of an established infestation is much better than applying sprays to a fixed planting, such as an orchard, in expectation of a sufficient infestation to cause damage—an expectation which, judging by past experience, may not be realized. As relatively small plants, 18 to 24 inches high, can be used in the tests, relatively small quantities of material are required to make several determinations.

During 1941 and 1942 unfavorable weather conditions and the unpredictable, erratic reactions of the beetles caused several failures. Storms destroyed the plants, and cool, cloudy, or rainy weather reduced the activity of the beetles. When conditions were favorable for flying and feeding, there was no assurance that the beetles would leave the plants in the vicinity and attack those in the experimental block. If they did attack the experimental plants, it was uncertain whether they would remain there for a sufficient number of days to allow completion of the test. Placing geranio-eugenol lures around and throughout the experimental blocks was not always effective in establishing an infestation on the experimental plants or in preventing the beetles from abandoning the experimental plants for more favored plants in the vicinity. Unless something was done to control the beetles and the environment, there was no assurance that much could

be accomplished during the short summer season.

TESTING IN CONTROLLED-CONDITION CHAMBER.—Early in the summer of 1943 a large chamber was arranged for the testing of sprays under controlled conditions. The chamber was 19 feet long, 14 feet wide, and 7 feet high. The walls and ceiling were painted with a high-gloss white enamel to reflect light. Eight 20-watt fluorescent tubes, in two rows parallel to the long axis of the chamber, were mounted on the ceiling. The floor was covered with 3 to 4 inches of moist white sand. The temperature, thermostatically controlled, was maintained at 80°F. and the relative humidity at 75 to 85 percent.

A latin square of test plants was set up in this chamber and 3000 freshly collected beetles were liberated. The beetles acted as they do on a warm sunny day in the field—feeding, mating, moving from plant to plant, and from time to time burrowing into the sand on the floor. The unsprayed plants and those sprayed with materials known to be of little value were defoliated in 48 hours; those sprayed with the recommended amount of lead arsenate were protected from severe attack. The chamber was operated continuously between June 28 and August 13, the period when beetles were available, and the results confirmed the value of the preliminary testing of repellents in this manner.

EXPERIMENTAL PROCEDURE.—Although randomized blocks and designs could have been used in this chamber, a latin square 7 by 7 was used. The test plants in 6-inch pots were set 28 inches apart on the long axis and 21 inches apart on the short axis of the chamber in order to cover the floor space and to have the outer rows and columns equidistant from the walls. Each of the 7 groups of pots was marked by a distinctive color. The positions of each color in the latin square were fixed throughout the summer by markers on the floor, but as the group of plants to which a treatment was applied was selected at random, the result was unbiased randomization of the different treatments. The arrangement of the colors in the latin square is given in table 1.

Twenty-four hours before beginning a test, 49 plants of smartweed, *Polygonum pennsylvanicum*, were selected for uniformity of size, density of foliage, and color. These plants were placed in the 6-inch pots marked with the distinctive colors. Each spray was prepared in 3-liter quantities and was applied to 7 plants. In applying a spray the 7 pots with a distinctive color were placed on a turntable and passed through the spray until the liquid began to drip from the foliage. Usually each plant passed 4 or 5 times through the spray. All the sprays were applied with a bordeaux nozzle, directed downward at an angle of 45° toward the plants, at a pressure of 20 pounds, the apparatus described by Chisholm (1939) being used. This operation was completed the day before the test was set up, so that the spray deposits would be thoroughly dry. Each series of tests contained 3 elements, (1) a group of unsprayed plants, (2) a group sprayed with lead arsenate and fish oil (lead arsenate 6 pounds, fish oil 1.5 pints, and water 100 gallons), and (3) 5 groups of test sprays.

Table 1.—The arrangement of the treatments in the latin square.

Row No.	Column						
	1	2	4	4	5	6	7
1	White	Blue	Orange	Yellow	Green	Gray	Black
2	Black	Orange	Yellow	Green	White	Blue	Gray
3	Green	Gray	Blue	Orange	Yellow	Black	White
4	Blue	Green	White	Black	Gray	Yellow	Orange
5	Yellow	Black	Gray	Blue	Orange	White	Green
6	Orange	White	Black	Gray	Blue	Green	Yellow
7	Gray	Yellow	Green	White	Black	Orange	Blue

Before each test was set up, all the dead and living beetles on the sand on the floor, remaining from the previous test, were removed and the chamber was aerated. The sand was then raked and watered to provide moisture for the plants and to facilitate the maintenance of humidity. Then the test plants, having been sprayed as described above, were set in their proper positions in the latin square. Finally 3000 freshly collected beetles were liberated from a shelf suspended from the ceiling near the center of the chamber. The beetles were usually liberated about 10 a. m. About 6 hours later, and at intervals thereafter, a record was made of the number of beetles on each plant and an estimate was made of the extent of feeding. These observations were continued until the unsprayed plants were practically defoliated, which usually occurred in 48 hours.

DISCUSSION OF RESULTS.—Variation is inherently involved in any biological

experiment. Although the gross uncontrolled variations introduced by changes in the weather and the competition of plants adjacent to the experimental block had been eliminated by conducting the tests under controlled conditions, there still remained the variation that is an attribute of a nonstatic group of beetles and also the variations introduced by the deposits of the different materials on the plants. To aid in evaluating deposit-introduced variations it was desirable that the other variables be of minor importance or be balanced so as not to influence the results seriously.

The normal daily cycle of movement of beetles from the ground to the plants in the morning and from the plants to the ground late in the afternoon was not interrupted in the chamber, but with continuous illumination there seemed to be a tendency for the beetles to remain later on the plants. In addition to this daily fluctuation of the population, natural mortality and poisoning caused a progressive decrease in the total number of active beetles. As the results were cumulative throughout the test period, these variations in the population are of relatively minor importance.

The distribution of beetles and the extent of feeding throughout the experimental block were not entirely uniform. There was a tendency for the maximum number of beetles and the most extensive feeding to occur on the outer columns of plants, and the minimum number of beetles and the least feeding on the plants in the three middle columns of the block. In the rows no clear-cut trend in feeding was evident. The position of a test treatment in the block was definitely a less important factor than the treatment applied, particularly when materials widely different in effectiveness were used. With proper replication of the treatments, the influence of position was largely eliminated.

It was evident that almost all the variation in the number of beetles on the plants and in the extent of feeding could be attributed to the nature of the deposit on the foliage. The effectiveness of competing sprays in the block had little influence on the performance of a treatment. A good spray was good when competing against other sprays equal in value or against fair or poor sprays. A poor spray was always poor, regardless of the other sprays in the block.

The number of beetles observed on plants and the extent of feeding varied somewhat from series to series. This variation can be attributed to the different numbers of beetles from the previous series that emerged from the sand, the recognized differences in the activity of different batches of beetles, and the nature of the sprays. In view of this condition, it is not possible to compare directly the effectiveness of two sprays unless they are tested simultaneously.

On the whole, the results obtained in this chamber were very satisfactory. By conducting the tests under controlled conditions many variables encountered in the field were eliminated or reduced in importance. The equipment also permitted an experimental arrangement that lends itself readily to a statistical analysis of the data.

INTERPRETATION OF RESULTS.—After considering various methods, the one to be described seemed to be the closest to that desired for the evaluation and the presentation of the results. In this work each spray was compared with lead arsenate and evaluated according to the relative reduction in the number of beetles on the plants and the relative protection of the foliage. A *repellent* may be defined as a material that would discourage beetles from coming to or remaining on a normal food plant, and a *protective agent* as a material that would afford protection to a susceptible plant. Both values are relative. No material has been found that is completely repellent or protective, although some sprays approach this condition very closely. The data taken from series 3 are presented in table 2 as an illustration of how the repellency and the protective value of the various sprays can be evaluated.

In reference to the number of beetles on the plants and the extent of defoliation, it may be assumed that within the range of inherent experimental variation the same number of beetles and the same extent of defoliation would have occurred on all treatments and on the unsprayed plants, except for the reactions of the beetles to the deposits on the foliage. The difference between the number of beetles on the unsprayed plants and on the plants to which a spray had been applied may be

considered as indicative to the number the spray had discouraged from coming to and remaining on the sprayed plants. In like manner the differences in the amount of feeding on the unsprayed and sprayed plants may be attributed to the effects of the spray deposits. Within a series it is only necessary to compare the number of beetles and the extent of defoliation on the plants sprayed with lead arsenate with the results obtained with the other sprays in the feeding after application of the lead arsenate spray was 94.4 percent, but in the different series the reduction ranged from 86.7 to 97.2 percent. When the effectiveness of a spray was expressed in relative terms, as compared with lead arsenate, it was found that compensation was made to a large extent for the variability between series, and the test sprays throughout the season were placed on practically a common basis.

Table 2.—Evaluation of sprays as repellents and protective agents against the Japanese beetle.

Treatment	Beetles Counted on Plants	Repellent Value: Reduction as Compared with Unsprayed Plants	Repellent Value: Relative Effectiveness as Compared with Lead Arsenate	Average Index of Defoliation	Protective Value: Reduction as Compared with Unsprayed Plants	Protective Value: Relative Effectiveness as Compared with Lead Arsenate
	Number	*Per Cent*	*Per Cent*		*Per Cent*	*Per Cent*
Unsprayed	708	—	—	93.6	—	—
Lead arsenate	150	78.8	100	2.6	97.2	100
Spray A	30[1]	95.8	122	1.7	98.2	101
Spray B	53[1]	92.5	117	2.1	97.8	101
Spray C	27[1]	96.2	122	1.7	98.2	101
Spray D	431[2]	39.1	50	45.0[2]	51.9	53
Spray E	162	77.1	98	12.4	86.8	89

[1] Repellency or protective value significantly more than that of lead arsenate.
[2] Repellency or protective value significantly less than that of lead arsenate.

and, from a consideration of the least significant differences, judge which sprays were inferior, equal, or superior to lead arsenate. Thus sprays A, B, and C were superior to lead arsenate in repellency and equal in protective power; spray E was not significantly different from lead arsenate, and spray D was distinctly inferior.

It was not physically possible to include in one series of tests all the sprays the author desired to compare, and, as significant differences occurred between the series, some method had to be devised to correct for these differences in order that all the data in the different series of tests obtained during the season could be put on a common basis. The extent of variability between the series may be illustrated by the lead arsenate, which was a common component of all series. The average number of beetles repelled by lead arsenate during the season was 78.8 percent but in the different series the repellency ranged from 57.5 to 92.7 percent, depending on the batch of beetles involved. The average seasonal reduction

SUMMARY AND CONCLUSIONS.—In the search for new and better sprays, it is not practical to conduct the preliminary tests with untried materials in commercial orchards and in other private plantings on the scale required to demonstrate their merits. A method requiring a relatively small amount of test material has been developed for the preliminary evaluation of the repellency of sprays against the Japanese beetle. The tests are conducted in the laboratory, under controlled conditions of temperature, relative humidity, and light, thus eliminating the effect of adverse weather conditions and the disruption of the experiments by the attraction of plants adjacent to the experimental block in the field.

A latin square 7 by 7 was set up in a large chamber, the floor of which was covered with moist sand. Each series included unsprayed plants, plants sprayed with lead arsenate, and 5 test sprays. A total of 3,000 beetles were liberated in the chamber and a record was made at intervals of the number of beetles and the extent of feeding for each treatment. The

effectiveness of each test spray was compared with that of lead arsenate and was evaluated according to the relative reduction in the number of beetles on the plants and the relative protection that was afforded the foliage from attack by the beetles.

An evaluation of a test spray can be completed in 48 hours, therefore considerable information on its effectiveness can be accumulated in a relatively short time. All preliminary information on the amount of a test material required in a spray, the resistance of the material to weathering, the reaction of the plants to the spray deposits, and other factors can be determined on a small scale in the laboratory, therefore large-scale field tests in the future can be limited to sprays showing the greatest promise in the preliminary tests.—1-1-45.

LITERATURE CITED

Chisholm, R. D. 1939. Laboratory spraying and washing apparatus. U. S. Bur. Ent. and Plant Quar. ET-149.

Fleming, W. E. 1934. Development of a standard cage methods for testing the effectiveness of stomach-poison insecticides on the Japanese beetle. Jour. Agr. Res. **48**: 115–30.

Tetralopha scortealis (Led.)[1] A New Insect Pest of Lespedeza[2]

F. W. POOS, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine,* and L. A. HETRICK, *Virginia Agricultural Experiment Station*

In recent seasons outbreaks of web-forming caterpillars on lespedeza in Virginia have caused some concern, especially among growers of lespedeza seed where damage has been severe. Since no previous references to *Tetralopha scortealis* (Led.) as an economic insect have been found, and because of the potential importance of the insect as a pest of this valuable legume crop, these notes and photographs are presented to bring it to the attention of entomologists.

So far as known this insect occurs only from Maryland to Florida. It is apparently a native insect and was described by Lederer in 1863 from specimens which he received from North America. The following synonymy was kindly furnished by Carl Heinrich:

Hemimatia scortealis Led., 1863, Wien. Ent. Monatschr. 7: 347, 459, pl. 7, fig. 12,

Pococera scortealis (Led.) Hampson, 1896, Roy. Ent. Soc., London, Trans.: 457.

Tetralopha scortealis (Led.) Barnes and McDunnough, 1917, Check List Lepid. Boreal Amer. (No. 5481). p. 142; Holland and Schaus, 1925, Ann. Carnegie Mus. 16: 65.

Benta slossonii Hulst, 1895, Canad. Ent. 27: 53.

Tetralopha slossonii (Hulst), in Dyar, 1902. U.S. Natl. Mus. Bul. 52: 416; Barnes and McDunnough, 1917, Contr. Nat. Hist. Lepid., N. Amer., 3(4): 220; Holland and Schaus, 1925, Ann. Carnegie Mus. 16: 66. [New synonymy.]

Tetralopha robustella Grossbeck (not Zeller). 1917, Amer. Mus. Nat. Hist. Bul. 37: 128.

Infestations of lespedeza by *Tetralopha scortealis* have been observed in Virginia and Maryland by the authors, in South Carolina by Paul Tabor, Soil Conservation Service, and in Georgia by T. L. Bissell. The distribution of *T. scortealis* does not appear to be restricted by soil types. The common name "lespedeza webworm" is proposed because the larvae form unsightly, tentlike webs on the infested plants (Fig. 1, *A*). Another insect pest of lespedeza, the tortricid *Archips obsoletana* (Walk.), in its early larval stages produces webbing somewhat similar to that of *T. scortealis*. However, *A. obsoletana* is actually a leaf tier, and by the time the webs become large enough to be noticeable it is easy to differentiate the two insects by the appearance of the webs. To the layman "lespedeza webworm" seems to describe *T. scortealis* adequately.

HOST PLANTS AND INJURY.—Although *Lespedeza cuneata* (*sericea*) is apparently the preferred host plant of *Tetralopha scortealis*, severe infestation has also been

[1] Order Lepidoptera, family Epipaschiidae.

[2] The authors are indebted to Roland McKee, of the U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, for the specific lespedeza names used here.

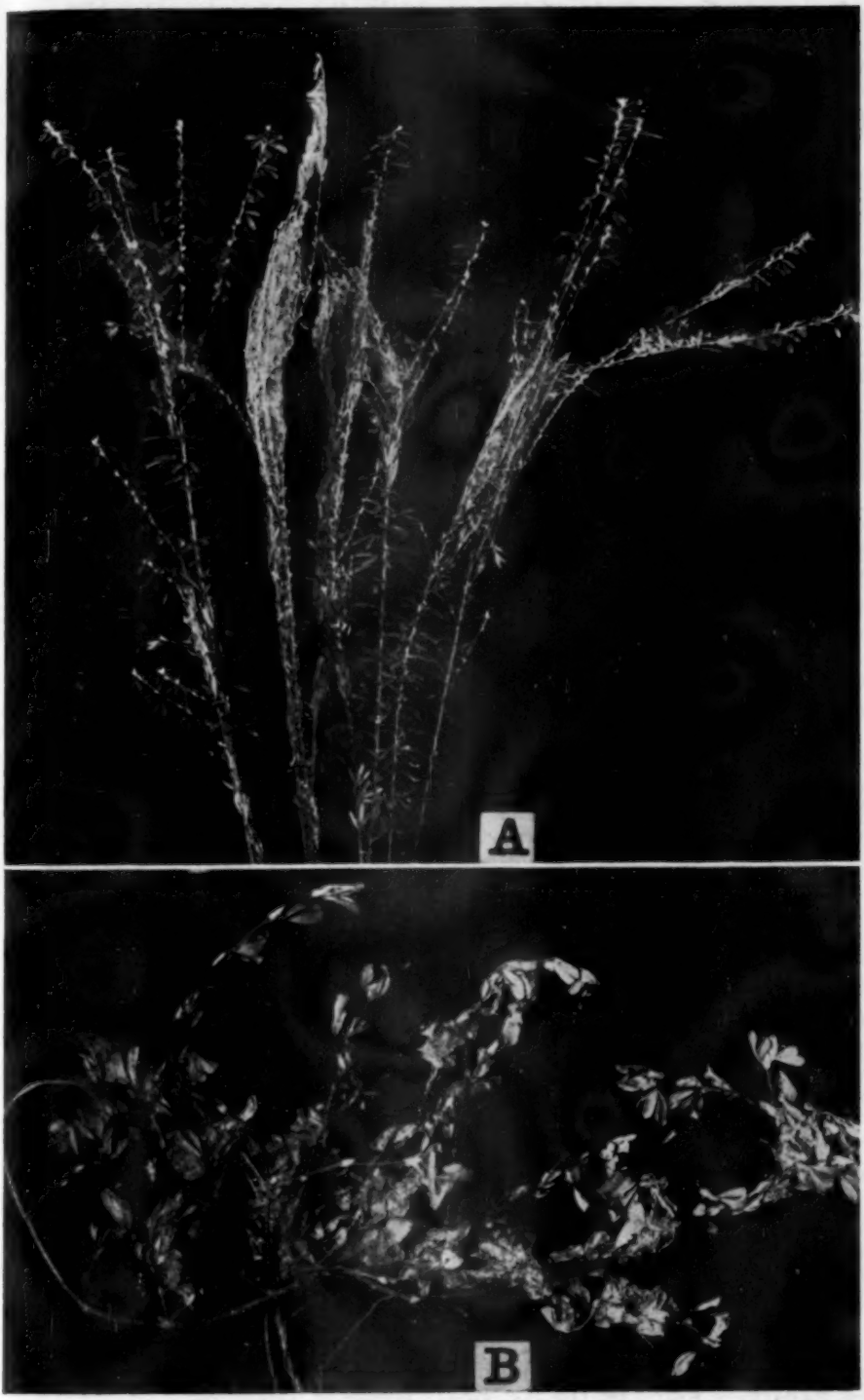


FIG. 1.—Injury by *Tetralopha scortealis: A*, Typical webs on *Lespedeza cuneata* (*sericea*) before the entire plants become enveloped in webs. *B*, Damage by larvae to Korean lespedeza in Surry County, Va., August 18, 1944.

observed on the hay varieties of Korean (*L. stipulacea*) (Fig. 1, *B*) and common lespedeza (*L. striata*). An examination of plantings of *Lespedeza cyrtobotrya*, *L. hedysarioides*, and *L. bicolor* showed that *scortealis* was found in the field, but larvae accepted it as a food plant under cage conditions.

Although the presence of webs is a hindrance in the proper curing of les-

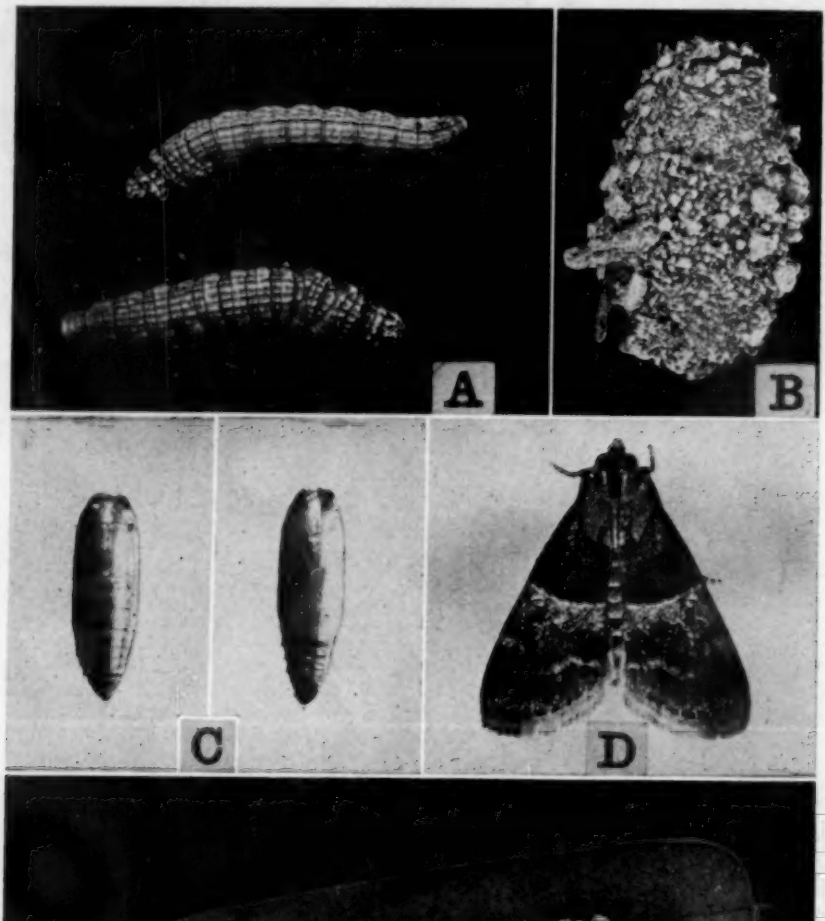


FIG. 2.—Stages in the life-history of *Tetralopha scortealis*: *A*, Larvae, probably fully grown, about 5×; *B*, Cocoon, about 6×; *C*, Pupae. Left, dorsal view; right, ventral view, about 4×; *D*, Adult, about 5×; *E*, Eggs, in situ, on center leaflet of lespedeza leaf, about 4×.

these species were also attacked, but only a few webs were found on the last two. Infestation has been observed on wild or native species of lespedeza and Desmodium. No infestation of alfalfa by *T.*

pedeza hay, greatest damage is done by larvae of *Tetralopha scortealis* consuming the leaves of the plant. Defoliation also greatly reduces seed production. Apparently most of the larval feeding and

web extension takes place at night, the larvae concealing themselves within their webs during the day. Most webs contain from 3 to 7 larvae, but webs have been observed that involved as many as 17 lespedeza stems and contained many larvae of different ages; obviously such large webs represent a fusing of a number of smaller webs.

SEASONAL LIFE HISTORY.—Two distinct and well-marked generations of *Tetralopha scortealis* have been observed in Virginia. There was also some indication of a partial third generation in the State, and even more may be produced under less severe climatic conditions. Webs and larvae (Fig. 2, *A*) of the first generation were present in the field late in June and early in July. After completing their feeding, larvae dropped to the surface of the soil, where they formed cocoons which were covered by sand or trash (Fig. 2, *B*). Pupation (Fig. 2, *C*) took place within the cocoons and adult moths (Fig. 2, *D*) emerged during the latter part of July and early August. On August 8, after an undetermined flight and preoviposition period, eggs (Fig. 2, *E*) were found abundantly on *Lespedeza cuneata* in the field. They were laid on the midrib of the upper surface near the distal end of the central leaflet of the trifoliate leaves. Occasionally eggs were deposited singly, but usually they were found in groups of 3 to 11. Incubation required only a few days. Webs of second-generation larvae were abundant during the latter part of August and most of September. Presumably the winter is passed in the prepupal stage within a cocoon. To date only one specimen (adult emerged May 24) has been successfully brought through the winter under insectary conditions.

CONTROL.—The most important factor in the natural control of this webworm is a disease that killed most of the larvae in September and may have prevented development of another generation. Heavy larval mortality has been observed in two seasons. In two lots of diseased material sent to the Bureau of Plant Industry, Soils, and Agricultural Engineering, only *Cladosporium* sp. (det. by Vera K. Charles) was found. This was considered secondary and not the cause of the disease.

Parasites of *Tetralopha scortealis* have not been found in abundance. Apparently the webs afford some protection against natural enemies. Hymenopterous parasites *Perilampus fulvicornis* Ashm. and *Haltichella*, n. sp. (det. by A. B. Gahan), were reared from pupae of *T. scortealis*. According to Mr. Gahan these may have been secondary parasites. Adults of a dipterous parasite, *Frontiniella parancilla* (Towns.) (det. by M. T. James), and two hymenopterous parasites, *Macrocentrus delicatus* Cress. (det. by C. F. W. Muesebeck) and *Triclistus fulvipes* (Cr.) (det. by H. K. Towns), were also recovered from cages containing larvae of *T. scortealis*.

Some preliminary insecticidal control tests were conducted in Surry County in a field of *Lespedeza cuneata* being grown for seed. Both an undiluted cryolite dust (not less than 83 per cent sodium fluoaluminate and 45 per cent fluorine) and a 2 per cent DDT dust killed the larvae. Two applications, one on August 8 and one on August 19, afforded excellent plant protection. Rotenone dust (0.5 per cent) applied on the same dates failed to give satisfactory control. Production of seed was obviously greater on plants treated with cryolite or DDT than on heavily infested untreated plants. A single application of either of these materials to badly webbed lespedeza as late as September 1 gave good control and obviously hastened recovery of the plants, although too late for the production of a normal crop of seed. More experimental data must be obtained before either of these materials can be recommended for use on fields of lespedeza to be harvested for hay. The greatest need in the control of this insect on lespedeza grown for seed appears to be the development of practical methods for applying the insecticides. —12-22-44.

QUARANTINES REVOKED

Utah's tomato pinworm quarantine order (No. 8) and Washington's order No. 21 pertaining to mosaic of raspberry and blackberry plants were revoked in March 1945.

Cost of Producing *Macrocentrus* by the Potato-Tuber-Worm Method[1]

HARRY S. SMITH,[2] *University of California Citrus Experiment Station, Riverside*

The immediate objective of the project herein discussed has been the maintenance of continuous populations of *Macrocentrus* in the various foci of infestation, as an adjunct to quarantine measures designed by the California State Department of Agriculture to retard the spread of the oriental fruit moth to clean areas. The ultimate objective is to develop means of producing *Macrocentrus* cheaply, in anticipation of the time when they will be needed for *control* rather than for retardation of spread.

A preliminary report (Finney *et al.* 1944) on the mass production of the parasite *Macrocentrus ancylivorus* Roh., with the potato tuber worm, *Gnorimoschema operculella* (Zell.), as host insect, dealt entirely with the technique originally developed for the purpose. At the time, little was known as to the numbers of *Macrocentrus* that could be produced in this way, or as to the cost of production. Obviously, both of these factors are of decisive importance in determining the practical utility of the method.

The first season's experience has been completed, and figures are now available which it is hoped will prove of interest, particularly to those entomologists concerned with the biological control of the oriental fruit moth.

Macrocentrus PRODUCTION FOR 1944.—Table 1 gives the figures for colonization of *Macrocentrus* for the year 1944, by counties and by months. As shown, the total number of *Macrocentrus* colonized during the year was a little over nineteen million. This does not include the parasites used as parent breeding stock, or those used for experimental work. The actual production amounted to well over 20 million. The figures in the table are estimates, but it is believed that the possible error is not in excess of 10 to 15 per cent. At the Albany, California, insectary, the figures were secured by estimating the number of moth cocoons per cocoon sheet, and then multiplying this number by the fraction that was parasitized. The latter figure was obtained by removing 1-inch-square sections of the cocoon sheets and actually determining the fraction of moth cocoons that contained parasite cocoons. At the Riverside insectary, a different method was used. Here, the adult parasites were colonized, rather than the parasite cocoons, and the number of adult parasites was estimated at the time of collection.

Collection of the parasites, from an illuminated cloth screen, into no. 12 paper bags lightly filled with excelsior, was ac-

Table 1.—Colonization records for *Macrocentrus ancylivorus*, 1944.
(In *thousands* of individuals)

COUNTY	MONTH							COUNTY TOTAL
	April	May	June	July	August	September	October	
Kern	59	143	687	767	593	619	419	3,287
Tulare	26	95	878	1,150	969	660	304	4,082
Kings					490	608	342	1,440
Fresno						532	367	899
Stanislaus	7	95	593	743	456	326	192	2,412
Sutter	11	153	792	1,130	529	383	293	3,291
Los Angeles		300	315	200	137	125	65	1,142
Riverside		60	225	150	165	92	65	757
San Bernardino		325	475	397	220	350	220	1,987
Monthly Total	103	1,171	3,965	4,537	3,559	3,695	2,265	19,297

[1] Paper No. 528, University of California Citrus Experiment Station, Riverside, California.

[2] Professor of Entomology and Entomologist in the Experiment Station.

complished by the use of a large aspirator having a mouth 1.5 inches across. The cloth screen was laid off in 6-inch squares, and practice made it possible to estimate with sufficient accuracy the number of parasites on each square.

PRODUCTION COSTS.—The cost of producing the parasites may be considered from several different angles. Most likely to be of interest to an entomologist, however, is that cost most nearly representing what, under present conditions, with established techniques, he might reasonably expect to be able to produce these for by the thousand, omitting charges for research. The principal items entering into this cost are housing and services,

FIG. 1.—Galvanized-iron production units arranged in double tiers on platforms movable with warehouse truck seen at left. (Photo by California State Department of Agriculture.)

equipment, salaries and wages, and supplies (primarily potatoes).

The cost of housing and of services varies so greatly, not only with the locality, but with the tastes of the individual entomologist, that no figure is given here. At both Riverside and Albany, structures which had been built for other purposes were remodeled to provide the necessary conditions of temperature, ventilation, etc., for use as insectaries. The requirements do not appear to be extremely exacting as far as temperature is concerned, if there is ample forced ventilation and sufficient circulation to prevent stratification of temperatures and consequent uneven development of insects at different levels in the rooms. (Finney *et al.* 1945).

As far as equipment is concerned, there is wide latitude. The production units described in the previously mentioned article (Finney *et al.* 1944) have been used with satisfaction throughout 1944. The cost of the complete units (box and tray) varied greatly. At Riverside, wooden units were used, and these, including painting, cost around $7.00 each. The units used at Albany were constructed entirely of galvanized iron (Fig. 1) and cost, roughly, $2.75 each. Most of the

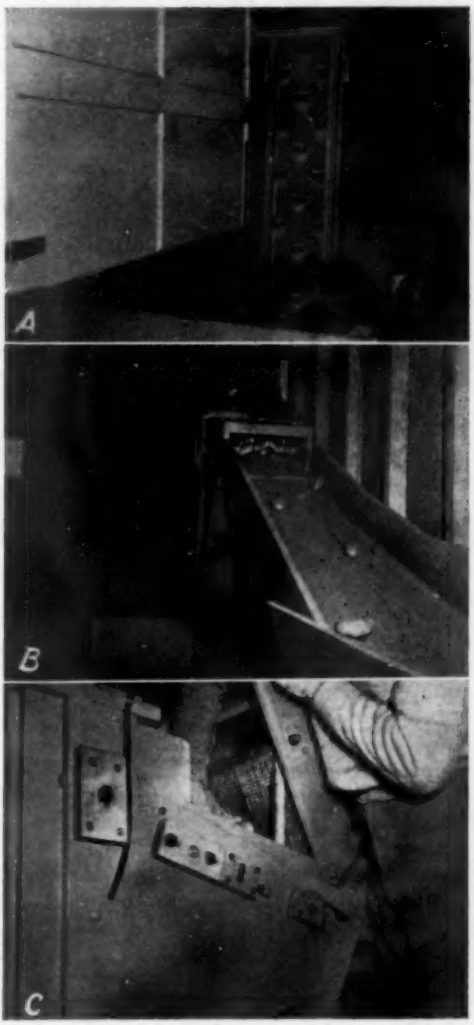


FIG. 2.—Potato-puncturing machine developed by the Division of Agricultural Engineering of the University of California. A, Elevator, which lifts potatoes from hopper to puncturing machine; B, potatoes passing through puncturer; C, detail of puncturing unit, showing metal arms studded with brads. A series of springs causes the arms to conform to the size and shape of the potato as it passes through. (Photo by California State Department of Agriculture.)

workers seemed to prefer the wooden units, but these certainly were not sufficiently superior to justify the extra cost.

At Riverside, 400 production units were operated; at Albany, 1,500. The total cost of these units, with which approximately nineteen million parasites were produced, was about $7,500. There is no reason why such units should not last several years. Depreciation charges should be calculated accordingly, for addition to production costs.

Labor is an important cost item in mass production of most parasites. Considerable progress has been made, however, in reducing this item by mechanization wherever possible. As an illustration, the Division of Agricultural Engineering of the University of California College of Agriculture designed and manufactured for us a machine for puncturing the potatoes (Fig. 2). This has completely eliminated what would have been a full-time job, if done by hand, on the 1944 scale. A mechanism for "sanding" the cocoon sheets has also been developed—an important labor-saving device which also does a much better job than is possible by hand.

Salaries chargeable to production are estimated at $5,000. This amount would provide for an insectary superintendent and an assistant superintendent. Since the work must be done every day in the week, two men are required for supervision.

Labor costs for the production of the nineteen million *Macrocentrus* in 1944 totaled, roughly, $7,335.[1] The labor was mostly female, at the rate of 75 cents per hour.

The principal expendable supply used in the mass production of *Macrocentrus* was, of course, potatoes. For the nineteen million *Macrocentrus*, 1,890 sacks (189,000 pounds) of potatoes were used, at an average cost, exclusive of transportation, of about 1½ cents per pound, or $2,835. For parasite production for orchard colonization, potatoes were used at the rate of 15 pounds per unit, an average of 63 units being loaded per day, for a period of 200 days. The low cost of the potatoes was due to the fact that so-called "peewees" and egg-sized tubers were found to be most suitable, and were considerably cheaper than the regular commercial grades.

The principal items in the cost of producing 19,279,000 (Table 1) *Macrocentrus* for orchard colonization were therefore as follows:

Salaries	$ 5,000
Wages	7,335
Potatoes	2,835
Total	$15,170

On this basis, the cost per thousand parasites was about seventy-eight cents ($0.78). To this cost would also have to be added proportionate charges for certain miscellaneous items such as freight on potatoes, depreciation of buildings and equipment, supplies such as cardboard and sand or other material for cocoon sheets, services such as heat, light, water, telephone, etc.

SUMMARY AND CONCLUSIONS.—Costs of production of over nineteen million *Macrocentrus ancylivorus* by the tuber moth method are given. These, itemized, were salaries, $5,000; labor, $7,335; potatoes, $2,835; a total of $15,170 or about seventy-eight cents per thousand. This was exclusive of depreciation on buildings and equipment, and of certain supplies such as cardboard and sand for the cocoon sheets, heat, light, water, telephone, etc.

As pointed out in the original article (Finney *et al.* 1944), the potato-tuberworm technique for rearing *Macrocentrus* is developing so rapidly that by the time descriptive material appears in print, many details of technique will have been superseded by improved methods. For a time, therefore, such articles are likely to prove of merely historical interest, as portrayals of the evolution of a process rather than of methods to be followed in detail. Recent studies having to do with the removal of the parasite cocoon from the tuber worm cocoon may completely revolutionize the present methods of production and transportation of *Macrocentrus ancylivorus*.

ACKNOWLEDGMENTS.—The funds for this investigation were appropriated by the California State Legislature to the State Department of Agriculture, which contracted with the University of California to carry on the study. The Uni-

[1] The reason it is not possible to give *exact* figures on this and other items is that we have attempted to exclude from the cost of production such items as are properly chargeable to research and development.

versity has produced the parasites and delivered them to the various sites of oriental fruit moth infestation, where they have been colonized by field men of the Department of Agriculture, or, in southern California, by the county agricultural commissioners.

The development of the technique for production and liberation of *Macrocentrus ancylivorus* is truly a joint contribution of the *staff* of the Division of Biological Control of the University of California Agricultural Experiment Station, particularly of the following: Blair Bartlett, Glenn L. Finney, S. E. Flanders, J. K. Holloway, C. H. Martin, and Harry S. Smith. The late David B. Mackie, of the California State Department of Agriculture, gave enthusiastic support to the project. The field colonization of *Macrocentrus* has been carried on by H. M. Armitage and his staff. The original stock of *Macrocentrus* was supplied by H. W. Allen of the U.S. Bureau of Entomology and Plant Quarantine. L. A. Burtch, agricultural commissioner of Kern County, was of great assistance in the purchase of potatoes.—12-14-44.

LITERATURE CITED

Finney, G. L., S. E. Flanders, and Harry S. Smith. 1944. The potato tuber moth as a host for mass production of *Macrocentrus ancylivorus*. JOUR. ECON. ENT. 37(1): 61–4.

Finney, G. L., C. H. Martin, and S. E. Flanders. 1945. The influence of moisture on the mass propagation of *Macrocentrus ancylivorus*. JOUR. ECON. ENT. 38(3): 319–23.

Flanders, Stanley E. 1943. The potato tuber worm, a host suitable for mass production of *Macrocentrus ancylivorus*. JOUR. ECON. ENT. 36: 807.

Influence of Moisture on the Mass Propagation of *Macrocentrus ancylivorus*[1]

GLENN L. FINNEY,[2] CHARLES H. MARTIN,[3] and STANLEY E. FLANDERS,[4]
University of California Citrus Experiment Station, Riverside

In 1944, during the mass propagation of *Macrocentrus ancylivorus* Roh. on the potato tuber worm, *Gnorimoschema operculella* (Zell.), in the insectaries of the University of California, it appeared that the density of the host populations, the percentage of parasitization, and the chronological difference in the attainment of the adult stage by host and parasite populations are markedly affected by differences in environmental moisture. As pointed out by Graf (1917), the tuber worm thrives best under arid conditions. The periodicity in outbreaks of the tuber worm in humid countries usually coincides with the occurrence of dry years.

The efficient reproduction and use of the tuber worm as a host required the attainment (1) of the maximum number of individuals per pound of potatoes and (2) of uniform development of individuals of equal age. Other things being equal, the critical factor involved appeared to be the rate at which the tissue of the infested tuber lost moisture.

The efficient parasitization of the tuber worm by *Macrocentrus ancylivorus* required high atmospheric humidity during the period of exposure.

THE CONTROL OF MOISTURE.—The amount and rate of moisture loss varies according to variety of potato, the density of the tuber worm infestation (a function of the number of punctures in the tuber) and the evaporative power of the surrounding air.

The effect of these factors on the propagation of the tuber worm and parasite is accentuated by the use of comparatively small containers or production units (Finney *et al.* 1944). The dryness of the air surrounding the potato, and consequently the rate of moisture loss, depends in part on the extent to which the container is made up of a moisture-transferring material, such as longcloth.

In the insectary at Riverside, three

[1] Paper No. 331, University of California Citrus Experiment Station, Riverside, California.
[2] Principal Laboratory Technician in the Citrus Experiment Station.
[3] Principal Laboratory Assistant in the Citrus Experiment Station.
[4] Associate Entomologist in the Experiment Station.

types of units have been used: type 1, with all sides consisting of longcloth; type 2, of wood, but with longcloth over the entire top; and type 3, of wood, but with cheesecloth over long narrow openings along two sides. Each type of unit contains a hardware-cloth tray holding about 15 pounds of egg-sized potatoes placed about an eighth of an inch apart. Beneath the tray is a layer of silt-covered cardboard, on which the tuber worms spin their cocoons.

The relative humidities of the incubation room housing these units varied between 40 and 65 per cent. Humidities either lower or higher were found to be unsatisfactory. The temperature was maintained between 80° to 85° F. The air in the incubation room was changed continually, the change of air being complete in less than 15 minutes. Uniformity in temperature throughout room was maintained by powerful electric fans.

Because of lower construction costs and simplicity in handling, the type-3 unit was the one most commonly used. In order to prevent condensation of moisture within this type of unit, it was found necessary to maintain a relative humidity in the incubation room of less than 50 per cent, *particularly when the potatoes were heavily infested.* Such potatoes are completely riddled by the time the worms become full grown. If aeration within the unit is then inadequate, the air becomes saturated and heating accompanied by the production of large amounts of gaseous ammonia occurs. The moisture which condenses on the upper surface of the unit causes the destruction of many tuber worms by trapping.

The Russet type of potato, apparently because of its cellular structure, is used most satisfactorily in the type-3 unit. Its tissues tend to lose water less rapidly from worm action than do those of the White Rose. However, when infested with worms of equal age, the total loss of water resulting from worm action is greater in the Russet than in the White Rose since the former supports a much greater worm population. The White Rose can be used satisfactorily, when the room humidity exceeds about 30 per cent, only in units such as type 1 or type 2, which permit a relatively high rate of evaporation. Potatoes in type-2 units lose 33 per cent more water than those in type-3 units, regardless of the variety. The weight of an egg-sized potato, therefore, may decrease over 75 per cent as a result of a tuber worm infestation.

The mass-production plant at Riverside, when operating 400 units at full capacity, used 3 tons of potatoes every 20 days, 20 units being emptied and refilled every day. The daily evaporation from the infested potatoes was estimated to amount to about 200 pounds of water. The temperatures in type-3 units, while worm infestations were young, were usually about 3 degrees lower than that of the air surrounding the units. The evaporation rate during the hot summer weather was sufficient to reduce the temperature in the incubation room during the heat of the day to a point 5 degrees lower than that of an adjacent room having the same source of air.

Examination of Russet and White Rose potatoes containing infestations 2 weeks old reveals a marked difference in the pith, that of the Russet being crisp, and that of the White Rose leathery. This difference is well known from a culinary standpoint, the Russet being "dry" (mealy) and the White Rose "moist" (soggy).

EFFECT OF MOISTURE ON TUBER WORM INFESTATIONS.—The Russet, a comparatively dry potato, can support a higher tuber worm population than the White Rose, a comparatively moist potato, provided the potatoes are infested only once and then with newly hatched worms. In newly dug potatoes development of the worm population is more rapid and much more uniform in the Russet than in the White Rose. Worms developing in White Rose appear to be more susceptible to attack by microorganisms.

In the Russet the worms tend to bore directly inward from time of hatching, and there is little competition between them. In the White Rose, however, the worms tunnel just beneath the surface of the potato if held in storage for several months the potato dries out sufficiently to enable them to penetrate deeper. During the period of surface-mining, there is apparently some reduction in worm population. This mortality is to some extent obviated by the use of smaller potatoes, which give an increased surface area per production unit. The maximum number of worms to reach the cocooning stage

in any unit was 13,000, in a type 3 unit containing Russet potatoes. In this unit 71 per cent of the worms were parasitized by an inoculum consisting of 100 females.

The amount of frass which the worms push out of their tunnels onto the surface of the potato is an indicator of the moisture conditions within: the greater the proportion of water, the larger the mounds of frass and the more worms within reach of the parasites.

EFFECT OF MOISTURE ON PARASITIZATION.—Since the Russet, under the limitations imposed by mass-production conditions, supports a higher worm population than the White Rose, it consequently yields a higher parasite population, provided the period of host availability is sufficiently long. This period, in the case of the Russet, is longer in the type-3 unit than in the type-2 unit, on the basis of the percentages of parasitization obtained, the higher humidity in the type-3 unit retarding the inward migration of the tuber worm.

The fact that high evaporation hastens the inward migration of worms into the potato and so out of the range of the parasite is strikingly evident when infestations on the Russet are inoculated with parasites 5 days, instead of 1 day, after the hatching of the moth eggs. When the Russet is used in the type-3 unit, the percentage of parasitization ranges from 90 per cent in units inoculated 1 day after hatching of eggs to 20 per cent in units inoculated 5 days after hatching of eggs.

The percentage of parasitization of Russets in type-3 units through which dry air (40 to 50 per cent relative humidity) is forced during the period of parasite oviposition may be extremely low (3 per cent or less), while in comparable units, through which air is not forced, parasitization may range between 20 and 30 per cent. Increasing the humidity increased the amount of oviposition by *Macrocentrus*. Even when White Rose potatoes were used it was found necessary, at room humidities between 20 and 40 per cent, to hold them in type-3 units to obtain a high parasitization.

In order to obtain the maximum parasitization of tuber worm larvae in Russet potatoes, particularly at humidities less than 60 per cent, it is necessary, because of the short period of host availability, to inoculate the units as soon as the moth eggs hatch. This short period of host availability also accentuates the adverse influence of another factor, namely, the pre-oviposition period of the parasites. Any variability in the pre-oviposition period of the parent stock is reflected in a variability in amount of parasitism.

When the White Rose is used, there is little if any advantage in early inoculation, except that early inoculation lessens the effect of the pre-oviposition period on parasitization. In fact, there may be a distinct disadvantage if superparasitization is detrimental to the host or favors the survival of the male rather than the female parasites. Units containing infested White Rose potatoes inoculated 5 days after the host eggs hatch have yielded extremely high percentages of parasitization.

EFFECT OF MOISTURE ON THE EMERGENCE DIFFERENTIAL.—Since the developmental stages of the tuber worm and its parasite in each production unit do not coincide but occur at different times, the collection of the adults and the subsequent release in the field of pure colonies of the parasites are greatly facilitated.

The collection, shipment, and release of the parasites is accomplished most readily while they are in their cocoons. Since the parasitization of a host population is rarely if ever complete, it is necessary to segregate the unparasitized hosts so that none are released with the parasites. Such segregation may be readily accomplished if the full-fed tuber worms are collected every 24 hours. Then moth emergence is completed before the emergence of the female parasites begins, provided Russet potatoes are used.

When development occurs in well-aerated units, at 80° F., the average life cycle of *Macrocentrus ancylivorus* is 3 to 7 days shorter than that of the tuber worm, depending on the age of the tuber worm when attacked.

When host larvae 10 to 14 days old are attacked, the peak of parasite emergence occurs 21 ± 1 days later; when hosts 5 to 9 days old are attacked, the peak of parasite emergence occurs 25 ± 3 days later. These peaks of parasite emergence, however, coincide under mass-production conditions for the reason outlined below.

The life cycle of the parasite is prolonged 1 to 4 days when the hosts attacked are less than 10 days old. This

prolongation occurs during the first instar, however, and since the parasite does not develop beyond the first instar until the host spins its cocoon, the prolongation has little if any effect on the differential in emergence between host and parasite.

Haeussler (1932) observed that the parasite larva emerges from its host, on an average, 3 days after the host would normally have pupated if unparasitized. Consequently, unparasitized hosts will have completed half of their pupal stage before the parasite larvae have finished feeding. Stearns (1928) and Daniel (1932) observed the differential between the emergence of the host and that of its parasite to be 7 days in the case of such hosts as the oriental fruit moth and strawberry leaf roller, whose life cycles differ from each other by 12 days.

Likewise, in the mass production of *Macrocentrus*, using the potato tuber worm, the peak of adult parasite emergence follows that of the tuber moth by 7 days. This differential is independent of the age of the host population at the time of the attack, provided none of the hosts has become immune.

Although the tuber worm population in the production unit may consist of individuals equal in age (measured in days), there is a great variation in rates of development, particularly in White Rose potatoes. An increase in the amount of infestation (because of its effect on the drying-out of the potato) tends to reduce such variation, provided the worms do not compete with each other.

Under mass-production conditions, however, the period of emergence of the adult host from the cocoon sheets is cut short, (1) because the infested potatoes are discarded before they are vacated by the slow-developing individuals, and (2) because of the destruction of worms by parasitization.

A high percentage of parasitization results in less overlapping in the emergence of host and of parasite.

In each production unit, oviposition by the parasite extends over a period of 7 days. This period, however, as noted above, is not reflected in the time of emergence of the parasite. Considerable variation in the rate of parasite development results from differences existing within the host; but such variation as is reflected in the emergence of adult parasites, occurs *after* the emergence of the host. A maximum difference of 17 days in the attainment of the adult stage occurred among the progeny of one female parasite, developing at a constant temperature of 80° F., from eggs deposited during 1 day in a 10-day-old host population.

The effect of dryness on the differential in time of host and parasite emergence is indicated by the following observations: (1) During the unloading of the mass-production units, many more immature, unparasitized larvae were noted in potatoes in humid units than in dry ones. (2) There was a greater differential in host-parasite emergence when type-1 units were used than when type-3 units were used. (3) Tuber worms in the Russet potato complete their larval development, and consequently their life cycle, about 1 day earlier than those in the White Rose. Presumably, this is an effect of the difference in moisture content, the moisture condition in White Rose causing the feeding period of the tuber worm to be prolonged.[1] It is possible, also, that conditions of dryness which cut short the period of development of the tuber worm, if extreme, may tend to prolong the development of *Macrocentrus*.[2]

It appears that the differential in emergence between host and parasite, *percentages of parasitization being equal*, is greater (1) with the Russet potato than with the White Rose, and (2) with the type-1 unit than with the type-3. Also, the higher the density of worm infestation, the more rapidly the potato dries out and the smaller the amount of variation in the life cycle of the worms. This is clearly demonstrated when infestations on punctured and nonpunctured potatoes are compared. It follows that the higher the density of the worm infestations, the greater the difference in emergence of moth and parasite, a difference that is accentuated by an increase in percentage of parasitization. It is obvious that the greatest differential in host and parasite

[1] It has been previously observed (Flanders 1930) that lepidopterous larvae, such as those of the lima bean pod borer which usually feed on succulent plant tissue, reach an early maturity when forced to feed on food that is partially dry.

[2] In experiments with the Indian-meal moth, *Plodia interpunctella* (Hbn.), and its parasite, *Nemeritis canescens* (Grav.), it was found that when the feeding larvae of the meal moth were attacked by *N. canescens* and then held at a temperature of 85° to 95° F. and a relatively low humidity, they pupated before the parasite completed its development, whereas if such parasitized host larvae were held at 65° to 85° F. and a relatively high humidity, they did not pupate before the parasite completed its development.—S. E. Flanders.

emergence occurs when all the host cocoons are formed at the same time.

SUMMARY.—In the mass propagation of *Macrocentrus ancylivorus* (Roh.) it was found that efficiency of propagation depended on the regulation of the evaporation of moisture from the potato infested with the potato tuber worm. The rate of moisture loss was determined by the variety of potato (being lower in the Russet than in the White Rose), the degree of infestation, and the amount of aeration.

Under conditions optimum for efficient propagation of *Macrocentrus ancylivorus*, the potato tuber, through evaporation, lost 75 per cent of its weight in 20 days.

A "dry" potato such as the Russet can be used efficiently when the evaporation power of the air is relatively low. A "moist" potato such as the White Rose can be used efficiently only when the evaporation power of the air is relatively high.

The difference in time of emergence of host and parasite populations may vary with the density of the host infestation, the percentage of parasitization, and the degree of uniformity in development of both the host and its parasite.

Low humidities, directly or indirectly, tend to inhibit oviposition by *Macrocentrus*.—12-14-44.

LITERATURE CITED

Daniel, Derrill M. 1932. *Macrocentrus ancylivorus* Rohwer, a polyembryonic braconid parasite of the oriental fruit moth. New York Agr. Expt. Sta. Tech. Bul. **187**: 1–101.

Finney, Glenn L., Stanley E. Flanders, and Harry S. Smith. 1944. The potato tuber moth as a host for mass production of *Macrocentrus ancylivorus*. JOUR. ECON. ENT. **37**: 61–4.

Flanders, Stanley E. 1930. The lima bean pod borer in California. California Dept. Agr. Monthly Bul. **19**: 409–21.

Graf, J. E. 1917. The potato tuber moth. U.S.D.A. Bul. **427**: 1–56.

Haeussler, G. J. 1932. *Macrocentrus ancylivorus* Roh. an important parasite of the oriental fruit moth. Jour. Agr. Res. **45**: 79–100.

Stearns, Louis A. 1928. The larval parasites of the oriental peach moth (*Laspeyresia molesta* Busck) with special reference to the biology of *Macrocentrus anclyivora* Rohwer. New Jersey Agr. Expt. Sta. Bul. **460**: 1–24.

The Role of the Spermatophore in the Mass Propagation of *Macrocentrus ancylivorus*[1]

STANLEY E. FLANDERS,[2] *University of California Citrus Experiment Station, Riverside*

A maximum percentage of parasitized hosts yielding a maximum percentage of *female* parasites is the goal in the mass propagation of parasitic insects. The attainment of this goal in the mass propagation of *Macrocentrus ancylivorus* Roh. on the potato tuber worm, *Gnorimoschema operculella* (Zell.), as developed by the University of California (Finney *et al.* 1944), under the direction of Professor Harry S. Smith, has been found to depend in part on the position and number of spermatophores[3] received by the female parasite. The malposition of the spermatophore may prevent the impregnation of the female parasite, and an excess number of spermatophores may cause the preoviposition period of the females to last longer than the period of host susceptibility to attack.

In the mass propagation of *Macrocentrus ancylivorus*, every unparasitized tuber-worm larva represents the loss of a parasite, and any excess of male parasites (derived from unfertilized eggs) represents the loss of that number of female parasites (derived from fertilized eggs).

Although the usual sex ratio of *Macrocentrus* under field conditions is 2 males to 3 females (Holloway 1934), the ratios obtained under mass production during the past year in the insectaries of the University of California were predominantly male, in some production units the proportion being as high as 10 males to 1 female. It has been important, therefore, to determine the factors causing male

[1] Paper No. 529, University of California Citrus Experiment Station, Riverside, California.

[2] Associate Entomologist in the Experiment Station.

[3] *Spermatophore:* a membranous sac formed by the secretions of the accessory glands of the male and enclosing a mass of sperm (Wigglesworth 1939). The spermatophore of *Macrocentrus ancylivorus* resembles in its shape an ixodid tick.

predominance and to eliminate them. This was the primary purpose of the present study.

Recent experiments by the writer have shown that impregnated females—that is, females possessing sperm in their sperm capsules—usually produce more females than males. In fact, such a female sometimes produces only female offspring.

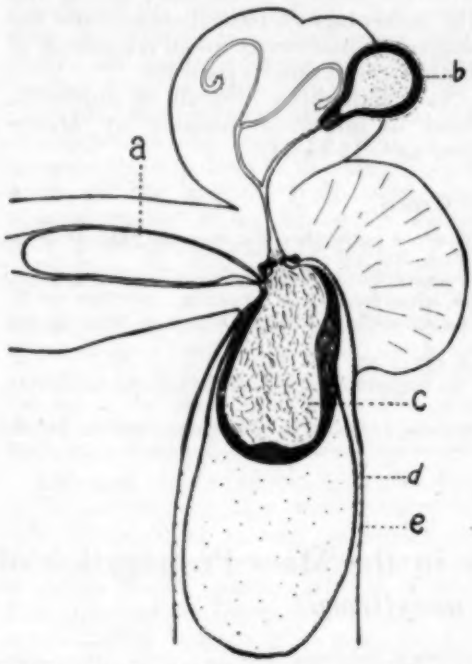


FIG. 1.—Diagrammatic drawing of spermatophore in position for the transfer of sperm to sperm capsule: a, egg in oviduct; b, sperm capsule; c, mass of sperm in pocket of spermatophore; d, spermatophore; e, vagina.

Sixteen impregnated females were isolated and each was provided every day of life with about 90 unparasitized and feeding host larvae. These females produced 4142 offspring having a sex ratio of 1 male to 2 females.

Sixty impregnated females were isolated and each was provided with feeding host larvae only once. These females produced 2846 offspring having a sex ratio of 1 male to 3 females. In this case, the low number of progeny per female resulted from the fact that the host larvae in from 1 to 5 days became immune to attack by *Macrocentrus ancylivorus* by outgrowing the stages in which they were susceptible to attack.

It was obvious that at optimum temperatures (70° to 80° F.) it should be possible to maintain a favorable sex ratio in mass-produced populations of *Macrocentrus* by maintaining the number of unimpregnated females at a minimum.

FACTORS AFFECTING FERTILIZATION.—*Macrocentrus ancylivorus* is characterized by its relatively large number of relatively small eggs and sperm. Most of the females of *M. ancylivorus* die of old age before the supply of ripe eggs in the ovary is noticeably diminished. The eggs in the ovary appear to be continually forming and disintegrating.

Disintegration of an egg (oösorption) is prevented only by ovulation. As each egg leaves the oviduct and enters the vagina, it passes through a mechanism so constructed that the probability of the egg's being fertilized is very high provided (1) that there are sufficient numbers of sperm in the sperm capsule, (2) that these sperm do not lack vitality, and (3) that the spermathecal glands produce secretions sufficient for the reactivation of the sperm.

It was observed that in only a few instances did impregnated females produce only male offspring. Lack of fertilization of the egg in females whose sperm capsules were filled with sperm may be accounted for by the presence of some external factor which inhibits the functioning of the spermathecal gland.

In most females of *Macrocentrus ancylivorus*, the spermathecal gland apparently is stimulated merely by the presence of eggs in the oviduct. This is indicated by the following facts: (1) The progenies of some females are all of the female sex. (2) The contact of the parasite with the host is limited to the tip of the ovipositor. (3) In species in which the fertilization of the eggs is known to be determined by host stimuli, the sperm gland empties directly into the sperm capsule or into the sperm duct at a point near the sperm capsule, and not, as in the case of *Macrocentrus ancylivorus*, at a point far removed from the sperm capsule (Fig. 1).

DIRECT EFFECT OF RATE OF OVIPOSITION.—The proportion of fertilized eggs deposited by impregnated females during the first and second days of oviposition is slightly higher than the proportion deposited from the third to eighth days, inclusive. This may be an effect of the

fewer eggs deposited during the first 2 days, the average per day being about 20, whereas the average per day for the next 6 days was about 30. The maximum number of eggs deposited in one day by any female was about 69, and of these, 17 were unfertilized.

It is possible that in the absence of multiple mating the length of the interval between ovipositions determines the proportions of sexes. If this interval is sufficiently long, all the eggs may be fertilized, provided that the sperm capsule contains an ample supply of sperm.

INDIRECT EFFECT OF THE DENSITY AND ACTIVITY OF PARASITE POPULATION.—Under conditions of mass production, every female parasite is likely to be mated. Tests have shown that at least 80 per cent of the virgin females 24 hours old readily mate. Aging of virgin females apparently has no effect on their readiness to mate. It has been observed, however, that many mated females lack sperm.

Dissection of 50 or more mated females indicated that this lack of sperm results from the malposition of the spermatophore received from the male.

At temperatures of about 80° F., the impregnation of the female is completed about 6 hours after the female receives the spermatophore. This is a critical period in reproduction, from the standpoint of sex ratio. Immediately after copulation, the female ceases to move about and appears to be engaged in adjusting the spermatophore so that it makes contact with the opening of the sperm duct leading to the sperm capsule. The spermatophore for a short time after being fixed in position is difficult to dislodge. Within 6 or 7 hours after mating, at temperatures of about 80° F., the spermatophore is emptied of sperm. During the transfer of sperm, the spermatophore becomes less firmly attached. Consequently, when the female is subjected to the stresses occasioned by crowding or by collecting with an aspirator, it is possible for the spermatophore to be dislodged before the sperm capsule is filled.

Under natural conditions it is probable that the females mate only once. In mass production, however, if the male population is relatively large and the temperature is above 80° F., 25 per cent or more of the females may mate several times.

In the studies on *Macrocentrus ancylivorus*, half-pint glass jars were used for confining the progenies of individual females until about 24 hours after such progenies became adult. It was found that in jars containing about 20 adult parasites, multiple mating commonly occurred if the number of males exceeded that of the females. Subsequently, if such females are placed in a large population of males, they continue to mate until the vagina is distended with spermatophores.

On the other hand, if the daily emergence in a jar consisted of 10 females and 1 male, multiple mating rarely if ever occurred. Such females, if placed in large populations of males, refused to mate, since each had mated only once while confined to the glass jar. Fourteen 11-day-old females, each of which had mated once and had then been held for 10 days in cages containing hosts suitable for parasitization, refused to mate when placed in a cage containing 60 newly emerged males. Fourteen 5-day-old virgin females mated immediately when placed in the same population of males.

Dissections of numerous females have shown that the crowding of spermatophores in the vagina may prevent any of the spermatophores from making connection with the opening of the sperm duct. As a result, many such overmated females remain unimpregnated.

For the sex ratios to be predominantly female, the transfer of the spermatophore from the male to the female must be followed by its adjustment to the sperm duct and by its retention until the sperm capsule is filled.

The effect of multiple mating is shown in table 1. It is evident that in order to prevent the production of excess males and consequently prolonged pre-oviposition, the causes of excessive activity, such as excessive heat, light, and density of parasites, should be eliminated during and for a short period after mating.

The application of the findings noted above to the mass propagation of *Macrocentrus ancylivorus* has resulted in sex ratios increasingly female.

The emergence of *Macrocentrus ancylivorus* occurs for the most part between 2 P.M. and 7 P.M. Emergence is artificially restricted to that period in order to get uniformity in mating. Although most of the females are mated by 7 P.M., they are not collected until the following morn-

Table 1.—Effect of single and multiple matings on impregnation and oviposition in *Macrocentrus ancylivorus* Roh. when period of host susceptibility was 7 days or less.

Test Description[1]	Ovipositing Females			Females Not Ovipositing Because of Prolonged Pre-oviposition Period
	Impregnated, Number	Not Impregnated		
		Number	Per Cent	
Females mated once and isolated immediately thereafter	18	3	14.2	3[2]
Females mated once and isolated immediately thereafter	18	4	18.1	2[2]
Females collected while mating and probably mated several times previously	8	7	46.6	9
Females probably mated several times	9	7	43.7	8

[1] Twenty-four female parasites used in each test.
[2] Dissection showed these females to be impregnated.

ing. The temperature of the emergence room is held between 70° and 75° F. The lighting is diffused until the time of collection, when additional daylight is admitted through the collecting screen.

In the species of Ichneumonoidea, in which the transfer of sperm from male to female is accomplished by means of spermatophores, it is possible, under the conditions of mass production, that upon the occurrence of a certain degree of male predominance in any generation there will result an increasing proportion of males, generation after generation, until reproduction ends with a generation consisting entirely of males. Clausen (1939) reports that such a situation has occurred in a number of biological control projects.

Effect of Superparasitism.—The presence of unimpregnated females resulting from multiple mating may nullify much of the work of impregnated females if superparasitism occurs. This is the most logical explanation of the fact that, in general, increases in percentage of parasitization have been correlated with increases in proportion of male parasites. An abnormally high proportion of males also occurs when potatoes containing nearly mature tuber-moth larvae are exposed to attack. Apparently, this is the result of superparasitism caused by smaller number of larvae near the surface and available to the parasite. When 100 virgin females and 20 males are placed in the production units, male progeny predominates. Although one male is capable of mating with 30 females, many unfertilized eggs are deposited before mating occurs. Such eggs apparently have precedence over fertilized eggs deposited later.

According to Daniel (1932), *Macrocentrus ancylivorus* attacks all stages of the feeding host larvae, depositing only one egg at each insertion of the ovipositor. Although this egg divides polyembryonically, only one of the embryos completes its development. When superparasitized, a host contains more than one egg and its separated divisions. Competition for the host occurs during the first larval instar of the parasite, the parasite remaining in the first instar until after the host spins its cocoon.

Effect of the Number of Spermatophores on Amount of Parasitization.—The prolongation of the pre-oviposition period (Table 1) is correlated with multiple mating, a condition which reduces or prevents oviposition under mass-production conditions, owing to the short (7-day) period of host susceptibility. A low percentage of parasitization results.

Most of the females of *Macrocentrus ancylivorus* have a pre-oviposition period of less than 5 days. In one test the pre-oviposition periods of 18 females were as follows: 1 day for 5 females, 2 days for 4 females, 3 days for 4 females, 4 days for 4 females, and 9 days for 1 female.

In another instance a female that had hosts available for 7 days failed to oviposit. Upon dissection this female was found to

contain a mass of seven spermatophores.

Within 14 hours after mating, the empty, collapsed spermatophore is ejected from the body of the female, probably through the copulatory ostium at the base of the ovipositor. Lack of oviposition results from the prolongation of the preoviposition period, caused apparently by the additional time required to break up the mass of spermatophores so that they can be readily ejected.

SUMMARY.—Studies with *Macrocentrus ancylivorus* Roh., and the application of the information obtained to the mass production of the parasite on the potato tuber worm, *Gnorimoschema operculella* (Zell.), show that the maximum amount of parasitization and the maximum percentage of female parasites can be obtained under mass-production conditions by eliminating the factors preventing impregnation of the female parasites. These factors, which include excessive heat, light, and parasite density, during and for a short period after mating, apparently prevent the proper placement of the spermatophore, or cause its premature dislodgment, and prolong the preoviposition period. The impregnation of the female appears to be dependent on the position of the spermatophore in relation to the sperm duct. The spermatophore is cast out of the body before oviposition occurs.

The progenies of unimpregnated females may dominate over the progenies of impregnated females when competing for the same host.—12-14-44.

LITERATURE CITED

Clausen, C. P. 1939. The effect of host size upon the sex ratio of hymenopterous parasites and its relation to methods of rearing and colonization. Jour. New York Ent. Soc. **47**: 1–9.

Daniel, D. M. 1932. *Macrocentrus anclyivorus* Rohwer, a polyembryonic braconid parasite of the Oriental fruit moth. New York Agr. Exp. Sta. Tech. Bul. **187**.

Finney, Glenn L., Stanley E. Flanders and Harry S. Smith. 1944. The potato tuber moth as a host for mass production of *Macrocentrus ancylivorus*. JOUR. ECON. ENT. **37**: 61–4.

Holloway, J. K. 1934. The sex ratio of *Macrocentrus ancylivorus* Roh. JOUR. ECON. ENT. **27**: 1196.

Wigglesworth, V. B. 1939. The principles of insect physiology. E. P. Dutton and Co., New York, N. Y.

Screwworm Survey of the Southeastern States in 1944[1]

W. G. BRUCE, *U.S.D.A., Agri. Res. Adm., Bureau of Entomology and Plant Quarantine*

A survey of the southeastern states for the screwworm, *Cochliomyia americana* C. & P., was initiated in 1943 by the Bureau of Entomology and Plant Quarantine with the cooperation of State agencies (Bruce 1944). This survey was continued throughout 1944.

The purposes of the survey were (1) to determine the incidence and relative abundance of screwworms (2) to ascertain the amounts of critical insecticides needed for screwworm control, (3) to aid in the proper distribution of these insecticides, and (4) to advise farmers and stockmen of the approved methods and materials for the treatment and prevention of screwworm infestations.

Two screwworm scouts spent their entire time on this survey contacting farmers, stockmen, county agricultural agents, veterinarians, manufacturers and dealers of screwworm remedies, and other interested agencies. Obviously it was impossible for two scouts to contact all the owners of livestock in the infested areas; however, enough farmers and stockmen were contacted to represent from 15 to 30 per cent of all livestock in each county. Upon this basis the incidence and relative abundance of screwworms were determined.

Screwworm infestations were more widespread in the Southeastern States in 1944 than in 1943, but the total number of cases and the death losses due to screwworm attack were considerably lower in 1944. Climatic conditions favorable to the development of screwworms enabled this pest to become established over a large portion of the southeastern states. A great many stockmen, however, put into

[1] Acknowledgment is made to A. L. Smith and C. C. Skipper, of the Bureau of Entomology and Plant Quarantine, for much of the information contained in this article.

effect the control measures recommended by the Bureau of Entomology and Plant Quarantine and thus contributed to a reduction in the number of infestations and resulting livestock death losses.

The shortage of experienced farm labor prohibited more effective screwworm control. Most of the cattle range in the open woods and were usually tended by riders, but wartime demands for manpower have deprived the stockmen of these cowhands, and cattle could not be properly tended. Consequently hundreds of screwworm cases were never treated.

Probably the most important factor contributing to the maintenance and

FIG. 1.—Screwworm survey of the Southeastern States in 1944.

build-up of screwworm populations is woods hogs. Thousands of these hogs roam the woods, most of them never cared for, and they are prolific breeders of screwworms. The principal places of screwworm attack in these hogs are the navels of pigs, the vulvas of their dams, and wounds caused by hog bites, bites from suckling pigs, dog bites, and scratches.

The incidence and relative abundance of screwworms in the southeastern states are shown in the accompanying map (Fig. 1). The shaded areas indicate the counties surveyed, and the various types of shading indicate the degree of infestation in each county. For simplicity of interpretation, the degrees of infestation are indicated as light, medium, and heavy. Infestations of 0.5 per cent or less are considered light and apply to those counties having only a few scattered cases. Infestations of 0.5 to 2.0 per cent are represented as medium, and infestations of over 2.0 per cent are represented as heavy.

FLORIDA.—Early in January heavy populations of screwworms were found in numerous areas in southern Florida, and a few scattered infestations were found in the rest of peninsular Florida as far north as the Georgia line. Most of these were in the navels of calves and pigs, such cases representing approximately 80 per cent of the total.

Infestations were abnormally high during February and March, but diminished considerably by July. The proportion of infestations in untreated wounds was about 90 per cent throughout most of the year. The survey had acquainted stockmen with the most effective methods for screwworm control and many stockmen applied these practices with an accompanying reduction in infestations and death losses. The total number of cases was kept fairly low in peninsular Florida for the remainder of the year except in areas where the Gulf Coast tick, *Amblyomma maculatum* Koch, was abundant. A very heavy build-up of screwworm populations occurred in western Florida during the summer and continued heavy until November. This area, from Tallahassee (Leon County), to DeFuniak Springs (Walton County), has been relatively free of screwworms for the past few years, therefore stockmen were unprepared for the outbreak and dealers had failed to stock adequate supplies of Smear 62.

During December screwworm activity was confined to the State of Florida. The number of screwworm cases at this time was the lowest for any one month since the survey was started in 1943, and, according to reports from stockmen, the lowest for the past 4 or 5 years.

GEORGIA.—Screwworms were reported to be active throughout the winter months of 1943–44 in the southern tier of Georgia counties. Infestations built up rapidly during May and June and soon spread to all counties in the southern three-fourths of the State, or as far north as Atlanta. Infestations were particularly abundant in the extreme southern and southeastern counties (see map), the former being a

hog-raising section and the latter a sparsely settled cattle area. Case incidence over the State ranged from 0.5 to 5 per cent of all livestock, except along the coastal plains area, where the Gulf Coast tick was active from August to October. As a result there were infestations in as high as 12 per cent of the cattle population in that area. Death losses from screwworm attack were reported to be light and certainly were very much lower than in 1943.

The total number of screwworm cases was kept fairly low and death losses were practically eliminated, owing to the fact that Smear 62 had been made available in practically all infested counties and that many stockmen had applied this remedy to wounds.

ALABAMA.—Screwworm flies migrated from western Flordia and southern Georgia into Alabama through Houston County in the southeastern corner of the State and spread to most counties in the southern third. Infestations were generally light and death losses negligible. Heavy infestations were found only in Houston County.

SOUTH CAROLINA.—Screwworm infestations in South Carolina were apparently the results both of natural migration of the screwworm fly from Georgia and of the shipment of infested cattle into Charleston. A few scattered cases were found in most of the counties but a majority were in the vicinity of Charleston. No death losses were reported.

MISSISSIPPI.—No infestations were found in western Alabama, hence it was not considered necessary to survey the adjoining State of Mississippi, especially since the Entomologist of that State was alert to the screwworm problem and cooperated in our screwworm survey and was ready to report to us any infestations coming to his attention. Only one case was reported from Mississippi (Greene County).

SUMMARY.—A screwworm survey of the southeastern states in 1944 revealed infestations throughout Florida, the southern three-fourths of Georgia, the southern third of Alabama, and in most of South Carolina. Screwworm activity was found throughout peninsular Florida as far north as the Georgia line during every month of the year. Stockmen in southern Georgia reported some cases each month during the winter of 1943–44. It is quite probable, therefore, that screwworms overwintered in southern Georgia.

Infestations reached outbreak proportions only in local areas in Florida and southern Georgia. Infestations in these areas, for the most part, appeared in navels of new-born animals, in castration, earmarking and branding wounds in the spring and in the lesions caused by the Gulf Coast tick in the late summer and early fall.

Climatic conditions were favorable for screwworm development until November, and this fact, combined with a shortage of experienced farm labor, contributed to the widespread distribution of screwworms in the Southeast. A large number of stockmen, however, put into practice the approved control measures, and this, in large part, was responsible for reducing the number of infestations and almost completely eliminating losses due to screwworm attack.

As a result of this survey, the incidence and relative abundance of screwworms in the southeastern states were determined, an estimate was obtained of needed critical insecticides and their adequate distribution was on assured, stockmen were acquainted with the most effective methods of screwworm control, and an important reduction of screwworm cases and accompanying livestock losses was accomplished.—3-13-45.

LITERATURE CITED

Bruce, W. G. 1944. Screwworm survey of the Southeastern States in 1943. JOUR. ECON. ENT. 37(5): 687–9.

EUROPEAN CORN BORER QUARANTINES

Greenhouse-grown chrysanthemums and the plants and greenhouse-grown rhubarb from corn borer infested areas are admissible in Arizona, Idaho, and Utah without the special inspection formerly required, according to modifications of the quarantines of these States which became effective early in 1945. The California quarantine also provides for the acceptance of cut rhubarb when greenhouse grown but places no restrictions under the corn borer quarantine against the entry of chrysanthemum.

Timing the Seasonal Cycles of Insects: The Emergence of *Rhagoletis pomonella*[1]

F. H. Lathrop and C. O. Dirks,[2] *Maine Agricultural Experiment Station, Orono*

Rhagoletis pomonella is an excellent example of a pest of considerable economic importance for the control of which insecticide applications are timed to coincide with certain phases of the seasonal cycle of the insect. In Maine the first spray application is generally recommended when approximately 0.1 per cent of the flies have emerged from the ground, and the second application is timed to coincide with the 50 per cent level of emergence. The accurate timing of the emergence of the flies, therefore, is of considerable importance.

In a previous paper (Lathrop & Dirks 1944), quantitative data presented showed that the seasonal cycles of several species of insects could be timed more closely by the use of a phenological scale rather than by calendar dates, and it was suggested that a phenological scale might be useful for the study of the effects of temperature and other climatic factors upon the seasonal cycles of insects. The present paper is a continuation of the study, in which the emergence of adults of *Rhagoletis pomonella* is considered in relation to temperature, rainfall, and date of petal-fall.

Sources of Data.—In the present study the data on emergence of the flies were obtained from cages, each cage covering an area of approximately one square foot. Heavily infested apples were placed over each cage area during late summer of the preceding year, and the larvae were allowed to enter the soil as they left the apples. Throughout the study, the cages were placed in a single apple orchard at Highmoor experimental farm, Monmouth, Maine. The orchard was on gently sloping land with sod cover. The study presented here covers 11 years, 1933–1943, inclusive. During the study, the emergence of a total of 132,129 flies was recorded.

The data on petal-fall were furnished by Dr. Donald Folsom, Plant Pathologist, Maine Agricultural Experiment Station (Lathrop & Dirks 1944).

Data on temperature refer to air temperatures recorded at Lewiston, Maine, about 12 miles from Highmoor Farm, as published by the U. S. Weather Bureau. Rainfall data are based in part upon records made at Highmoor Farm, and in part upon U. S. Weather Bureau records for Lewiston for the periods during which records for Highmoor Farm are not available

Seasonal Pattern of Emergence.—The emergence of adults of *Rhagoletis pomonella* follows a characteristic seasonal pattern, that varied at the 50 per cent level only to the extent of approximately 9 days from the mean during the period of eleven years upon which the study is based. When plotted, the cumulative emergence of adults takes the form of an S curve (Lathrop & Dirks 1944, Fig. 2). The shape of the curve shows an interesting similarity to the form of curve encountered in toxicity studies (Bliss 1935, Fig. 2). The similarity in shape of the two curves appears to result from parallel causes. Just as the toxicity curve is the result of variation in the individual response, or susceptibility, of the insects to the toxic substance, so the emergence curve indicates variation in the response (susceptibility) of the individual to environmental influences such as temperature and rainfall. The variation in emergence of the insects probably results in part from differences in the exposure of the individual insects; for example, differences in position with respect to sunshine and shade, the depth at which the insects occur in the soil, the nature of the soil, and perhaps many other factors. To an important degree, however, the variations also appear to be the result of distinctive differences in the physiological response of the individual insects.

In many of the published studies of temperature and moisture in relation to the development of insects, primary consideration has been given to the time required for the completion of a given stage, or for the development of the insect from birth to the production of the first offspring (Sanderson & Peairs 1913, Peairs 1914, Glenn 1922, Lathrop 1923, Shelford

[1] Diptera, Trypetidae, the apple maggot.

[2] The authors are indebted to Miss Mildred Covell, Technical Assistant, Maine Agricultural Experiment Station, for her able and generous assistance with the statistical work involved in this paper.

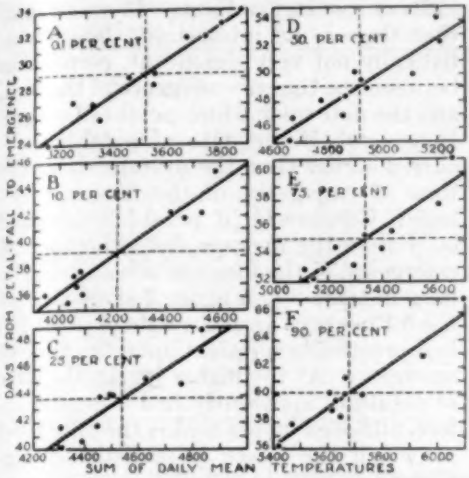


FIG. 1.—Date of emergence in relation to the summation of daily mean temperatures (Fahrenheit) during the period from 30 days before petal-fall to the time of emergence of each percentage indicated.

In each of the figures, 1 to 3, the heavy bar represents the regression line, the broken lines represent means, and each point locates the data for one year. The period covered includes 11 years, from 1933 to 1943 inclusive.

Table 1.—Date of emergence in relation to the summation of daily mean temperature during the period from 30 days before petal-fall to the time of emergence of each percentage indicated. The study covers 11 years, 1933–1943, inclusive.

EMERGENCE LEVEL (PERCENTAGE)	MEAN TIME OF EMERGENCE (DAYS AFTER PETAL-FALL)	AVERAGE SUM OF DAILY MEAN TEMPERATURES (FAHRENHEIT)	r
0.1	29.3	3524.7	.9683*
10.0	39.2	4223.1	.9557*
25.0	43.8	4544.2	.9188*
50.0	49.2	4917.2	.9162*
75.0	55.2	5338.5	.9112*
90.0	60.2	5682.1	.9509*

* When r exceeds .602, the correlation is considered significant.

1927). The problem presented here is to follow the flow of emergence of the flies through the season, and to estimate with reasonable accuracy the time of emergence of any given percentage of the total. In broaching the problem it seems feasible to consider each level of emergence, for example, 0.1 per cent, 50 per cent, 90 per cent, etc., somewhat as a separate stage in the development of the insect; each level exhibiting a distinctive reaction to the environmental factors. A more or less independent study, therefore, seems necessary for each level of emergence.

INFLUENCE OF TEMPERATURE.—The relationship between emergence and temperature is represented here as a straight-line correlation (Fig. 1, Table 1) in which the time of emergence is plotted against the summation of the daily mean temperatures for a period extending from 30 days before petal-fall to the time of emergence. In analyzing the data, summations of temperatures were tried for longer and for shorter periods, but the highest correlation was obtained for the period beginning 30 days before petal-fall, and ending with emergence at the level under consideration. The highly significant correlation is interesting, and emphasizes that temperature is a most important factor influencing the seasonal flow of emergence of the flies.

It is realized, as found by many previ-

Table 2.—Date of emergence in relation to the total rainfall during the period from 30 days before petal-fall to the time of emergence of each percentage indicated.

EMERGENCE LEVEL (PERCENTAGE)	MEAN TIME OF EMERGENCE (DAYS AFTER PETAL-FALL)	AVERAGE TOTAL RAINFALL (INCHES)	r
0.1	29.3	6.02	.6506*
10.0	39.2	6.98	.7357*
25.0	43.8	7.27	.7628*
50.0	49.2	7.51	.6496*
75.0	55.2	8.60	.3370
90.0	60.2	9.23	.0509

* When r exceeds .602, the correlation is considered significant.

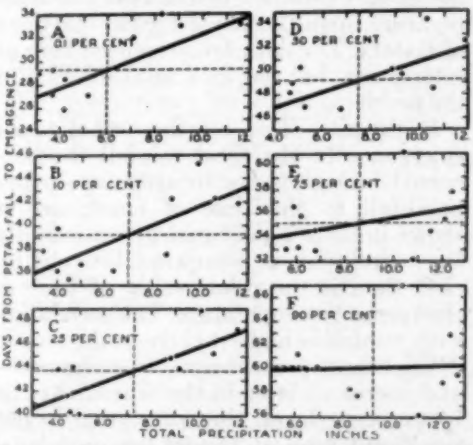


FIG. 2.—Date of emergence in relation to the total rainfall (inches) during the period from 30 days before petal-fall to the time of emergence of each percentage indicated.

Table 3.—Date of emergence in relation to the date of petal-fall.

EMERGENCE LEVEL (PERCENTAGE)	MEAN TIME OF EMERGENCE (DAYS AFTER PETAL-FALL)	AVERAGE DATE OF PETAL-FALL	r
0.1	29.3	30.3	−.0611
10.0	39.2	30.3	−.4706
25.0	43.8	30.3	−.4785
50.0	49.2	30.3	−.4176
75.0	55.2	30.3	−.5501
90.0	60.2	30.3	−.6664*

* When r exceeds .602 without regard to the sign, the correlation is considered significant.

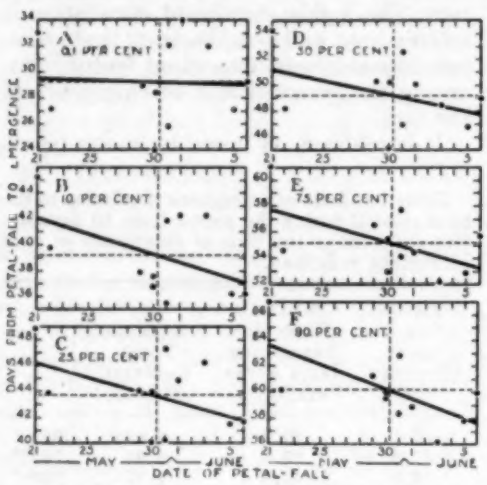


FIG. 3.—Date of emergence in relation to the date of petal-fall.

ous workers, that the simple summation of daily mean temperatures does not give the closest estimate of the effect of temperature upon the physiological reactions of insects. The data are presented here as interesting, but not as a final solution of the problem.

RAINFALL.—The relation of date of emergence to the total rainfall that occurred during a period from 30 days before petal-fall to the time of emergence is shown in table 2 and figure 2. Statistically the correlation is somewhat less significant than is the relationship of time of emergence to temperature. The correlation with rainfall is highest early in the season —the lowest percentages of emergence— and decreases later in the season. At the 75 per cent level, the correlation is not significant, and at the 90 per cent level there appears to be practically no correlation between time of emergence and rainfall.

DATE OF PETAL-FALL.—It was found that there is an interesting, though statistically not very significant, correlation between the time of emergence of the flies, and the date upon which petal-fall occurs. In general, if the date of petal-fall occurred earlier than the average date, the time of emergence of the flies was delayed. Conversely, if petal-fall occurred later than the average date, the time of emergence of the flies was advanced. The data in table 3 and figure 3 show that at the 0.1 per cent level the date of petal-fall had practically no effect upon the time of emergence. At the higher levels, the date of petal-fall apparently had a greater effect, although 90 per cent is the only level at which the effect is statistically significant.

The data appear to indicate that, on the average, the emergence of flies begins at about the same time with respect to petal-fall, regardless of whether petal-fall occurs early or late. In seasons when petal-fall occurs early, emergence may be expected to continue over a relatively longer period than in seasons when petal-fall occurs late. This suggests that in more southerly localities, the emergence of the flies may be expected to continue through a slightly longer period than in more northerly localities, but the beginning of emergence may be expected to occur at about the same time with respect to petal-fall, regardless of latitude.

DISCUSSION AND PRACTICAL APPLICATION.—Tables 4, 5, and 6 show a comparison of three methods of estimating the time of emergence of the flies at the levels of 0.1 per cent, 50.0 per cent, and 90.0 per cent, respectively. The greatest errors (column A) occur when the estimate is based upon the mean calendar date. By using the mean number of days after petal-fall, instead of the mean calendar date, the errors (Column B) are decidedly reduced. When the effects of temperature, rainfall, and date of petal-fall are considered, the errors (Column C) generally are again reduced.

The estimates shown in column 1, tables 4, 5, and 6 are derived by a summation of the daily mean temperatures from 30 days before petal-fall until the respective total for the percentage of emergence under consideration is attained. The average totals for the 11 years of the study were observed to be 3524.8, 4917.2,

Table 4.—Comparisons of methods for estimating the emergence of *Rhagoletis pomonella* at the 0.1 per cent level.

Emergence by Calendar Date	(A) Deviation from Mean Calendar Date (Days)	Emergence	(B) Deviation from Mean	Emergence by (1) Temperature estimate	(2) Rainfall estimate	(3) Date of petal-fall estimate	Mean of 1, 2, 3	(C) Errors of Estimate (Days)
				Days after petal-fall				
1933 June 26.0	− 1.5	29.0	− .3	29.9	27.1	29.4	28.8	− .2
1934 June 24.9	− 2.6	25.9	−3.4	28.5	27.9	29.2	28.5	+2.6
1935 July 4.0	+ 6.5	32.0	+2.7	29.9	30.1	29.1	29.7	−2.3
1936 June 26.5	− 1.0	28.5	− .8	27.9	27.9	29.3	28.4	− .1
1937 July 1.1	+ 3.6	32.1	+2.8	29.4	33.5	29.3	30.7	−1.4
1938 June 22.0	− 5.5	24.0	−5.3	29.1	29.3	29.3	29.2	+5.2
1939 July 4.3	+ 6.8	29.3	.0	28.8	27.6	29.0	28.5	− .8
1940 July 1.1	+ 3.6	27.1	−2.2	30.3	28.7	29.1	29.4	−2.3
1941 June 17.2	−10.3	27.2	−2.1	31.0	27.5	29.6	29.4	−2.2
1942 June 22.0	− 5.5	33.0	+3.7	28.8	31.6	29.6	30.0	−3.0
1943 July 4.0	+ 6.5	34.0	+4.7	29.5	31.0	29.2	29.9	−3.1
Standard error of estimate	± 5.77		±3.34					±3.17

Table 5.—Comparisons of methods for estimating the emergence of *Rhagoletis pomonella* at the 50 per cent level.

Emergence by Calendar Date	(A) Deviation from Mean Calendar Date (Days)	Emergence	(B) Deviation from Mean	Emergence by (1) Temperature estimate	(2) Rainfall estimate	(3) Date of petal-fall estimate	Mean of 1, 2, 3	(C) Errors of Estimate (Days)
				Days after petal-fall				
1933 July 17.3	− .2	50.3	+1.1	50.6	47.7	49.5	49.3	−1.0
1934 July 16.0	−1.5	47.0	−2.2	47.9	47.8	49.1	48.3	+1.3
1935 July 20.5	+3.0	48.5	− .7	49.2	51.1	48.4	49.4	+ .9
1936 July 13.1	−4.4	45.1	−4.1	48.7	47.7	49.3	48.6	+3.5
1937 July 21.5	+4.0	52.5	+3.3	48.5	51.9	49.1	49.8	−2.7
1938 July 17.7	+ .2	49.7	+ .5	49.6	50.3	49.3	49.7	.0
1939 July 24.0	+6.5	49.0	− .2	48.7	47.5	47.8	48.0	−1.0
1940 July 20.8	+3.3	46.8	−2.4	50.3	48.8	48.0	49.0	+2.2
1941 July 8.2	−9.3	48.2	−1.0	50.2	47.4	51.0	49.5	+1.5
1942 July 13.3	−4.2	54.3	+5.1	50.5	50.9	51.2	50.8	−3.5
1943 July 20.1	+2.6	50.1	+ .9	47.2	50.1	48.9	48.7	−1.4
Standard error of estimate	±4.59		±2.75					±2.53

Table 6.—Comparisons of methods for estimating the emergence of *Rhagoletis pomonella* at the 90 per cent level.

Emergence by Calendar Date	(A) Deviation from Mean Calendar Date (Days)	Emergence	(B) Deviation from Mean	Emergence by (1) Temperature estimate	(2) Rainfall estimate	(3) Date of petal-fall estimate	Mean of 1, 2, 3	(C) Errors of Estimate (Days)
				Days after petal-fall				
1933 July 27.3	−1.1	61.3	+1.1	61.5	60.0	60.7	60.7	− .6
1934 July 27.4	−1.0	58.4	−1.8	58.9	60.2	59.9	59.7	+1.3
1935 July 28.2	− .2	56.2	−4.0	59.8	30.3	58.8	59.6	+3.4
1936 July 28.1	− .3	60.1	− .1	60.3	60.1	60.3	60.2	+ .1
1937 July 31.9	+3.5	62.9	+2.7	59.0	60.4	59.9	59.8	−3.1
1938 July 27.6	− .8	59.6	− .6	60.3	60.4	60.3	60.3	+ .7
1939 Aug. 4.0	+6.6	60.0	− .2	59.4	60.1	57.7	59.1	− .9
1940 July 31.8	+3.4	57.8	−2.4	61.0	60.1	58.0	59.7	+1.9
1941 July 20.2	−8.2	60.2	.0	61.0	60.2	63.3	61.5	+1.3
1942 July 26.0	−2.4	67.0	+6.8	61.4	60.3	63.7	61.8	−5.2
1943 July 28.9	+ .5	58.9	−1.3	59.9	60.4	59.6	59.9	+1.0
Standard error of estimate	±3.79		±3.02					±2.88

5682.1 for 0.1 per cent, 50.0 per cent, and 90.0 per cent of emergence, respectively.

The estimates of emergence based upon rainfall (Column 2, Tables 4, 5, 6) are derived by substituting in the regression formula the total rainfall that occurred during the period from 30 days before petal-fall until the date estimated in column 1.

The emergence estimates based on date of petal-fall (Column 3, Tables 4, 5, 6)

were derived by substituting in the regression equation the date on which petalfall occurred.

The final estimate was based upon the mean of columns 1, 2, and 3 rather than by using the multiple correlation method, because the derivation of the mean involved a very simple computation and appeared to give results as satisfactory as did the multiple correlation.

As a practical method for timing the applications of insecticides for the control of the apple fruit fly, the results of the study were reasonably satisfactory in each of the 11 years included, except for the 0.1 per cent level in 1938, and the 90 per cent level in 1942. In the future it should be possible by the use of the method to time the emergence of the flies within satisfactory limits, except for infrequent years when an exceptional combination of climatic factors may introduce a wide error in the estimate.

It is not to be expected that many growers will attempt to estimate the dates of emergence of the flies in their orchards. The estimates can be made for fruit-growing communities by qualified workers and the information passed on to the growers. It is to be expected that there may be purely local variations in the dates of emergence, arising from factors such as topography and soil characteristics. Timing the dates with relation to apple petalfall should help to meet problems arising from such local factors.

It is worthy of note that the use of U. S. Weather Bureau data, so generally available, may be useful for estimating the time of emergence of the flies. It seems probable that the Weather Bureau can make predictions of temperature and rainfall several days in advance, and it may be feasible to employ such forecasts in the prediction of the emergence dates of the flies.—12-14-44.

LITERATURE CITED

Bliss, C. I. 1935. The calculation of the dosage-mortality curve. Annals Applied Biology. **XXII**: 134–67.

Glenn, Pressley A. 1922. Codling Moth Investigations of the State Entomologist's Office. Ill. State Natural History Survey. **XIV**: 219–88.

Lathrop, F. H. 1923. Influence of temperature and evaporation upon the development of *Aphis pomi* De Geer. Jour. Agr. Res. **XXIII**: 969–87.

Lathrop, F. H. and C. O. Dirks. 1944. Timing the seasonal cycles of insects. JOUR. ECON. ENT. **37**: 199–204.

Peairs, L. M. 1914. The relation of temperature to insect development. JOUR. ECON. ENT. **7**: 174–9.

Sanderson, E. D. and L. M. Peairs. 1913. Relation of temperature to insect life. New Hampshire Agr. Expt. Station. Tech. Bul. **7**.

Shelford, Victor E. 1927. An experimental investigation of the relations of the codling moth to weather and climate. Ill. State Natural History Survey **XVI**: 311–440.

The Arizona sweetpotato weevil quarantine (Order #6) was revised effective January 5, 1945, to remove from the designated infested area 113 counties in the Gulf Coast States, as well as one entire State (Kentucky), and to add a single county McIntosh, Georgia, to the designated infested area

---

Cherry fruitfly quarantines of Idaho and Utah, as revised in March 1945, have for their purpose the adjustment of the designated infested areas. The list of Oregon infested counties is uniform as to both quarantines. Four Idaho counties are listed as infested under the quarantine of that State; three are so designated in the Utah quarantine. There are also slight discrepancies in the Washington list of infested counties.

Following the 1944 survey for oriental fruit moth infestations in the Western States, the quarantines of Arizona, California, Colorado, Idaho, Oregon, Utah, and Washington have been extended to include additional counties, to add *Cotoneaster pannosa* and *Photinia serrulata* to the list of host plants, and to make certain modifications in the requirements for shipping nursery stock.

The Oral Secretions of the Pineapple Mealybug[1]

WALTER CARTER
Pineapple Research Institute, University of Hawaii, Honolulu

The oral secretions of sucking insects of the orders Homoptera and Hemiptera are responsible for many pathological conditions in plants which vary in symptom expression from tiny discrete spots at the insect's feeding points to systemic conditions such as psyllid yellows and mealybug wilt (Carter 1939).

When the problem is complicated, as it is in the case of *Pseudococcus brevipes* (Ckl.), with evidence for a number of distinct secretion effects as revealed by the symptom picture, it can be assumed that the oral secretions of that insect are complex and differ in their physiochemical properties. With the development of a technique for feeding the insect artificially, a new experimental approach became available.

ARTIFICIAL FEEDING.—Most of the methods for feeding sucking insects artificially go back to those described by the writer some 15 years ago (Carter 1927; 1928). In these methods the insect is fed by enclosing a solution in an animal mesentery which permits the insects to feed through it. Unfortunately, this method and many modifications of it have failed with *Pseudococcus brevipes* and it was by chance that it was found that mealybugs would settle and feed on solid agar gels. The procedures are quite simple if a few precautions are observed. The agar should be made up at not less than 2 per cent strength. The surface of more dilute agar is too soft to permit the mealybugs to feed without entangling their tarsi in the agar, an observation which suggests that mealybugs brace themselves with their feet when penetrating tissue with their mouth parts. Agar at 2 to 3 per cent strength has proved most satisfactory; at greater strength there is trouble with too rapid drying out and cracking. Solid agar gels lend themselves to easy manipulation and blocks can be cut, shaped and drilled to suit special needs.

One method is illustrated in figure 1. Here, the agar is cut into a rectangular block slightly smaller than a large cover-slip. By placing a cover-slip on the top, the mealybugs can be confined to the edges of the agar block. In a second method, a hole is drilled in the block which is then covered with a perforated cover-glass. The hole in the agar is made by inserting a cork-borer for perhaps half the thickness of the block, then digging out the agar so that the hole has an irregular floor. As syneresis of the agar frequently occurs, an irregular-floored hole was found necessary to permit the water of syneresis to drain into the hollows, thereby avoiding the drowning of mealybugs which would otherwise occur. Syneresis, which seems to be increased as a result of the mealybug feeding, can be largely avoided by making up the agar blocks several hours before using.

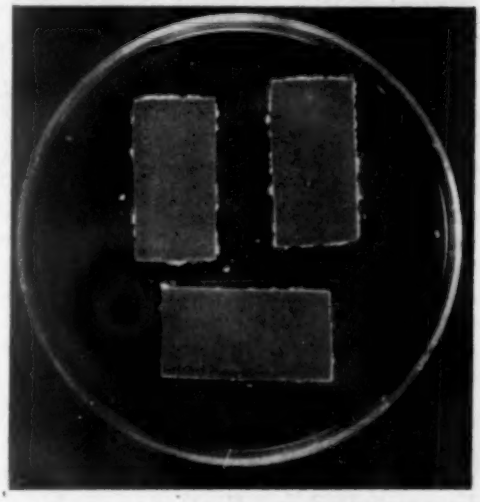
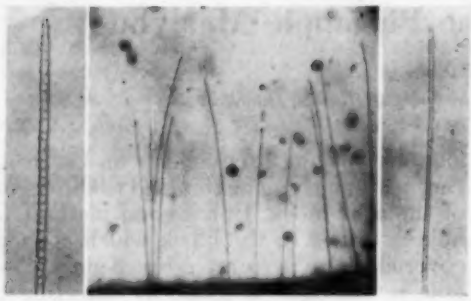


FIG. 1.—Mealybugs feeding on agar blocks, covered with glass cover-slips to localize the feeding on the edges of the blocks.

The mealybugs may also be fed upon liquid media through a thin agar film. The film is made by dipping a wire screen into hot agar. The wire screen, fitted onto a ring, is set in a petri dish, containing a thin layer of water. The thinness of the agar film permits the mealybug to insert its mouthparts into the liquid below. A modification of this method is to set a thin layer of agar, cut from a solid block, over

[1] Published with the approval of the Acting Director as Technical Paper No. 159 of the Pineapple Research Institute of Hawaii.



(B) (A) (C)

FIG. 2.—(A) Thread-like feeding tracks deposited by mealybugs on agar blocks. (B) and (C) Single feeding tracks under high magnifications.

a ring and place it in a petri dish in such a way as to permit an introduction of a small quantity of water at the bottom of the dish. Another modification is to stretch broadcloth by means of an outer metal ring and an inner celluloid ring after the manner of embroidery hoops. When stretched, the cloth is dipped in hot agar and allowed to cool, the process being repeated until a sufficient thickness of agar is built up.

The technique has one serious limitation in that highly nutritive media cannot be used since it is obviously impossible to maintain sterile conditions after the mealybugs are introduced. For that reason, most of the experiments have been conducted with agar gels to which no nutrient material was added.

FEEDING TRACKS IN AGAR BLOCKS.—Many sucking bugs leave a well-defined feeding track in the plant tissue. There has been a good deal of controversy as to the nature of this track. It is apparently a tubular structure, more or less regular, left behind by the insect after it finishes feeding. Some workers consider that it is a reaction product on the part of the plant, but workers with the sugarbeet leafhopper have demonstrated the coagulation of drops of secretion which were introduced by the insect into a liquid feeding medium (Fife 1932).

The insertion of mouthparts into the agar occurs almost immediately after the mealybugs are introduced on the agar plates and when these are withdrawn, a feeding track is left behind. These feeding tracks are clearly of insect origin. They are formed by the exclusion of droplets of saliva which harden and through which the mouthparts of the mealybugs pass on to produce more of these droplets which finally leave a tube rather roughly corrugated on the outside and smooth inside where the mouth parts have effectively reamed out a perfectly clear channel. The feeding tracks are tubular; they can be dissected out *in toto* from agar blocks and this would seem to settle effectively the question as to their insect origin.

When a mealybug's mouthparts enter a pineapple leaf, the insect is guided to certain tissues on which it feeds. The tracks found in the leaf show that their course is a straight one through the parenchyma but then becomes tortuous, going from fibro-vascular bundles to fibers and on to other fibro-vascular bundles. The stimuli for this selection of tissues are, of course, absent in a plain agar block so the track is straight except for very rare instances where there are slight jogs or curves (Fig. 2).

EVIDENCE OF THE DIFFUSION OF ELEMENTS OF THE SECRETION.—The feeding track definitely locates the immediate area fed upon by the insect but symptoms caused by this insect's feeding obviously involve more than the actual area fed upon (Carter 1933, 1933a, 1944) so that it is necessary to postulate either a catalysis at the feeding point or an actual diffusion of elements of the secretion beyond the feeding point.

The following experiments using radioactive phosphorus as a tracer element demonstrated that diffusion can occur. The radioactive phosphorus (P^*) was obtained from the Crocker Radiation Laboratory, Berkeley, California.[1]

METHODS OF DETERMINING THE PRESENCE OF P^*.—The presence of radioactive phosphorus was determined by two methods, one electroscopic and the other photographic. The electroscopic method was used as described by Ballard & Dean (1940) and through the courtesy of Dr. L. A. Dean the same apparatus was used in this study.[2]

[1] The writer is indebted to Dr. E. O. Lawrence and Dr. Martin Kamen of the Crocker Laboratory for the supply of material and to Miss Eder Lindsay of the University of Melbourne for some useful suggestions on laboratory methods.

[2] Briefly, a Lauritsen quartz fiber electroscope is first charged by means of a vacuum tube rectifying charging unit. The electroscope deflection caused by the radioactivity of the material is then measured in terms of time required to pass a given number of divisions of the electroscope scale. "Background" is the deflection of the electroscope which occurs as a result of atmospheric influences. The significant measure is therefore the increased rate of deflection over that of the background.

EVIDENCE OF P* IN MEALYBUG TISSUES.—When mealybugs are fed on agar containing P*, then smeared onto slides and tested photographically, very positive results can be obtained. If separate organs are dissected out and smears made, the presence of P* can also be shown. It is of interest to note from figure 3 that the mycetome of the mealybug, which is presumably ductless, shows positive evidence for the presence of P*.

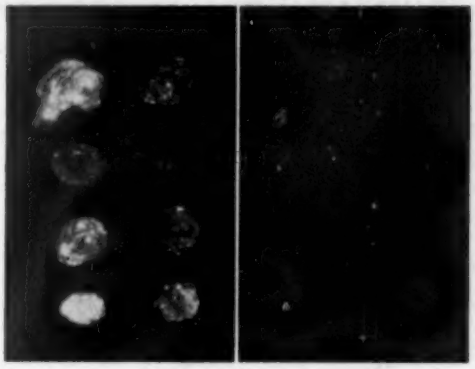
TRANSFER OF P* FROM ONE AGAR BLOCK TO ANOTHER.—This was accomplished by first feeding the mealybugs on an agar block which had been made up to include radioactive sodium phosphate. The mealybugs were confined to the edges of this block and fed thereon for 6 days after which they were removed to a new block which contained no P*. Two days later the radioactivity of the new block to which the mealybugs were attached, was measured, with positive results.

Ten days after the mealybugs were first set on the plain agar block, the edges of the block to which the mealybugs were attached were cut away and the remaining portion tested for radioactivity. The results showed clearly the presence of P* in the area of the block to which the mealybugs had not had access. The data from this experiment are shown in table 1.

Table 1.—Transfer of P* from a P* impregnated agar block to a plain agar block by mealybugs. Mealybugs fed on a P* agar block for 6 days before transfer to a plain agar block.

Days of Feeding on a Plain Agar Block	Electroscope Readings		
		Divisions	Time
2	Agar block with mealybugs attached	5	17′42″
	Background	5	42′8″
10	Agar block with mealybugs attached	5	20′16″
	Agar block after edges had been removed	5	26′0″
	Background	5	44′59″

RECOVERY OF P* FROM ROOTS OF PLANTS.—Mealybugs were first fed upon P* agar for 6 days and then transferred to plants growing in water vapor culture boxes (Carter 1942). The roots and the leaves on which the mealybugs has fed were cut off at intervals, ashed in a muffle, and tested. The shortest time elapsing before positive results were obtained from the roots was 31 days (Table 2). It should be noted that the quantity of P* recovered from the leaves was very much greater than from the roots.



(A) (B)

FIG. 3.—Presence of radioactive phosphorus in mealybugs which had fed on P* agar. Photographic positives obtained by exposing smears to photographic film (A) whole insects and (B) mycetomes and intestinal tracts.

Table 2.—Recovery of radioactive phosphorus from plants which had been fed upon by P* charged mealybugs.

Days Elapsed After Infestation with Mealybugs	Electroscope Readings			
	Leaves	Roots	Background	Divisions
31	—	35′11″	64′0″	5
33	11′22″	13′26″	21′27″	10
33	2′2″	50′28″	70′8″	10
39	2′0″	19′17″	41′34″	5
39	1′0″	20′7″	41′34″	5

Recovery of P* from roots was accomplished in a much shorter time when plants were injected with P* by means of capillary tubes, very positive results being obtained in as short a period as 12 days.

USE OF NITROGEN IN THE AGAR BY THE MEALYBUGS.—This is indicated by the following nitrogen readings taken from the inner portion of blocks of agar which had been fed upon. The agar was made up using distilled water without additives of any kind. After the mealybugs had been fed for 3 days on one lot of agar they were transferred to a newly made lot for a second feeding lasting 4 days. Comparable portions from these blocks and untreated check blocks were analyzed for the nitrogen content (Table 3).

Table 3.—Loss in nitrogen content of agar after feeding by mealybugs.

NITROGEN IN PARTS PER MILLION	
Check agar blocks	Agar fed on by mealybugs 3 days
32	27
33	28
33	29
34	29
34	31
Check agar blocks	Agar fed on by mealybugs 4 days
29	26
31	27
32	28
33	30

DISCUSSION.—The deposition of feeding tracks and at the same time the diffusion of other elements of the secretion beyond the feeding track is evidence for the complexity of the secretion. Whether or not the nutrition of the insect affects the quality of the secretion is a fundamental question to which only passing reference can be made now.

It seems clear, however, that at least some fractions of the secretion are independent of nutrition or at least of complete nutrition, since the feeding track is laid down during successive transfers to plain agar as long as the insect lives, the striping of pineapple leaves recently recorded (Carter 1944) has resulted from the feeding of mealybugs which had previously been maintained on a plain agar gel for 6 and 7 days, and no change in the capacity of mealybugs to cause green spotting has been noted as a result of artificial feeding.

SUMMARY.—The method of artificially feeding *P. brevipes* is described. The feeding tracks of *P. brevipes* are deposited in plain agar gels. Additional elements of the oral secretions of the insect diffuse beyond the area of agar gel actually fed upon. The presence of radioactive phosphorus can be shown in tissues of mealybugs, is transferred from one agar gel to another by mealybugs and can be recovered from the roots of plants which have been fed upon by mealybugs charged with P*. Artificial feeding of mealybugs on plain agar gels does not affect the ability of the insect to deposit feeding tracks, or to produce green spotting or striping of pineapple leaves.—12-6-44.

LITERATURE CITED

Ballard, S. S. and L. A. Dean. 1940. The use of radioactive phosphorus in soil studies. Jour. of Appl. Phys. **11**(5): 366–70.

Carter, W. 1927. A technic for use with homopterous vectors of plant disease, with special reference to the sugar-beet leafhopper, *Eutettix tenellus* (Baker). Jour. Agr. Res., **34**(5): 449–51.

Carter, W. 1928. An improvement in the technique for feeding homopterous insects. Photopath. **18**(2).

Carter, W. 1933. The ineapple mealybug, *Pseudococcus brevipes* (Ckl.) and wilt of pineapples. Phytopath. **23**(3): 207–42.

Carter, W. 1933. The spotting of pineapple leaves caused by *Pseudococcus brevipes* (Ckl.), the pineapple mealybug. Phytopath. **23**(3): 243–59.

Carter, W. 1939. Injuries to plants caused by insect toxins. The Botanical Review. **5**(5): 273–326.

Carter, W. 1942. A method of growing plants in water vapor to facilitate examination of roots. Phytopath. **32**(7): 623–5.

Carter, W. (1944). A striping of pineapple leaves caused by the feeding of *Pseudococcus brevipes* (Ckl.). JOUR. ECON. ENT. **37**(6):

Fife, J. M. 1932. A method of artificially feeding the sugar-beet leafhopper. Science **75**(1948): 465–6

PEACH TREE DISEASES

Peach mosaic quarantines of Arizona, California, Texas, Oklahoma, and Utah have been revised in 1945 to remove from the regulated area three counties in Texas and one in Utah, in which the disease is no longer known to exist, and to add to the regulated area one county in New Mexico and two in Oklahoma, which were first found infected in 1944. Similar quarantine action against this disease was taken by the State of Oklahoma effective December 15, 1944.

Arizona, California, and Idaho have modified their quarantines against entire States infected with peach yellows, peach rosette, and little peach, by providing that when annual surveys have been carried on in the infected States, which have determined that certain counties are free from these diseases, and the State of destination is satisfied with the adequacy of the surveys, and when the host plants have been produced from disease-free sources and environs, then the restricted plants may be admitted under certification to this effect. These revisions became effective early in 1945.

Effect of Foods on Ovarian Development in the Melon Fly

RALPH H. MARLOWE, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During the last few years a large number of melon flies *Dacus cucurbitae* (Coq.), were reared in the laboratory located at Honolulu for use in studies on toxicity. In these rearings it was noted that the number of eggs laid by individual females varied, depending on the food given and on the season of the year. The effect of diet on the development of the ovaries in daily. In the second series a solution of sucrose or molasses was fed to the flies and changed as often as needed. A microscopic examination of the ovaries was made as the females died, or those surviving for 30 days were killed and the ovaries examined. During these studies the temperature ranged between 70° and 75° F. The 30-day period was selected because

Table 1.—The effect of various foods on ovarian development in the female melon fly.

Type of Food	Flies in Cage	Mortality; 30-Day Period	Ovarian Development in Flies Alive After 30 Days		
			None	Partial	Complete
Cut cucumber	30	73.3%	12.5%	50.0%	37.5%
Cut papaya	19	15.8	6.2	62.5	31.3
Cut tomato	56	7.1	3.8	36.6	59.6
Cut orange	40	0	7.5	40.0	52.5
Cucumber juice	66	24.2	16.0	48.0	36.0
Cucumber juice+tartar emetic (120 p.p.m.)	50	100.0[2]	0[4]	0	0
Cucumber juice+yeast[1]	54	11.1	22.9	54.2	22.9
Molasses,[3] 5 per cent solution	46	41.3	100.0	0	0
	60	16.7	100.0	0	0
Molasses, 5 per cent solution+yeast	68	11.8	100.0	0	0
Papaya juice	52	3.8	94.0	6.0	0
Tomato juice	57	3.5	7.3	25.4	67.3
Orange juice	60	3.3	50.0	44.8	5.2
Sucrose	32	34.4	100.0	0	0
	23	43.5	100.0	0	0

[1] Pulverized dried Chinese yeast.
[2] Flies all dead at end of 27 days.
[3] Hawaiian blackstrap cane molasses.
[4] No development of ovaries up to 27 days.

Diptera has been noted by other investigators. Dorman, *et al.* (1938) studied the relation between temperature, diet, and egg production in the flesh flies. Allman (1940) noted the effect of poison baits on the Queensland fruitfly. Back & Pemberton (1917) found that melon flies began mating on the tenth day when fed on sliced cucumber, but required 20 or more days when fed on papaya juice and water. In view of these observations preliminary studies were made on the effect of food on the development of the ovaries, and on the effect of low concentration of tartar emetic on egg production.

TECHNIQUE.—Populations of newly emerged melon flies were placed in screen cages (10-inch cubes). Moist cotton in petri dishes served as a source of water supply. Two types of food were provided. Flies of the first series were fed on fruit juice or sliced fruit which was changed

C. B. Keck[1] has shown that the preoviposition period of flies fed on papaya and cucumber juice ranges from 15 to 41 days at 70° and from 12 and 20 days at 75°.

LONGEVITY.—In the absence of food and water melon fly adults die within 4 days. If kept well supplied with fresh cucumber juice and water, the adults frequently live for more than a year (Back & Pemberton 1917, and Keck).[1] In the experiments now reported the longevity of the adults varied with the type of food. A summary of the data is presented in table 1.

It will be noted that the use of cut cucumber resulted in a high mortality during the 30-day period. In this case 43 per cent of the deaths occurred on 1 day. The introduction of the previous day of a sliced cucumber having soft spots around the ovules and placenta was probably the

[1] Unpublished data, 1941.

reason for this high mortality, as the cucumber slice became slimy before the end of the day. The mortality of flies feeding on cut papaya and tomato was low, with no mortality for the lot fed on cut orange. Flies fed on cucumber juice changed daily showed 24.2 per cent mortality in 30 days. Tartar emetic (120 p.p.m.) added to cucumber juice resulted in 100 per cent mortality by the end of the 27th day. The addition of yeast to the cucumber juice slightly reduced fly mortality. Molasses and sucrose solutions resulted in mortalities ranging from 16.7 to 43.5 per cent.

Sliced fruits and fruit juices were found to be better food for the melon fly than solutions of molasses and sucrose.

The ovaries of females fed on sucrose or on molasses solution did not show signs of development. The addition of yeast to the molasses solution or to the cucumber juice did not have an accelerating effect on development. Ovaries of flies fed on tomato juice and sliced tomatoes completed development in 67.3 and 59.6 per cent of the cases. Those of flies fed on sliced orange came next with 52.5 per cent. No ovarian development occurred in flies fed sucrose, molasses solution, molasses solution plus yeast, or cucumber juice plus tartar emetic (120 p.p.m.). However, flies fed on cucumber juice and examined after 27 days revealed ovaries fully developed and containing eggs.

In another series studies were made to compare development of the ovaries over a 90-day period. This study was started on February 27, 1941, when two cages of melon flies were selected at random from a stock of newly emerged flies. Sliced cucumber and water were given to one lot, sucrose and the water to the other. At various times during the study females were killed and their ovaries examined. The data are summarized in table 2.

In the flies that fed on the juice of cut cucumber, the ovaries showed some development on the 9th day. At 19 days there were 2 females out of 10 in which the ovaries contained eggs. There was no development of the ovaries in the females fed on the sucrose, even after 90 days.

Table 2.—Effect of cucumber and sucrose on development of the ovaries of the melon fly.

Age of Flies (Days)	Number of Flies in Sample	Number of Females in which Ovarian Development Was—		
		Zero	Partial	Complete
	Cucumber			
3	50	50	0	0
9	50	44	6	0
13	50	42	8	0
19	10	3	5	2
26	10	2	6	2
90	—	—	—	—
	Sucrose			
3	50	50	0	0
9	53	53	0	0
13	60	60	0	0
19	55	55	0	0
26	87	87	0	0
90	15	15	0	0

These data show that the absence of certain substances in the diet of the melon fly retards the development of the ovaries. Lack of ovarian development in flies fed cucumber juice plus tartar emetic (120 p.p.m.) indicates that the presence of certain chemicals in the diet may also retard development of the ovaries. This fact represents an interesting aspect of the chemical control of certain insects. Although a chemical may not be lethal, or, if lethal, the insect may take only a sublethal dose, the reproduction potential may be lowered.

SUMMARY.—The type of food on which the melon fly fed influenced the rate of development of the ovaries. Normal development occurred in flies fed on fruit juice, but in females fed on sucrose or molasses solution no development of the ovaries resulted in 30 days. Tartar emetic (120 p.p.m.) in cucumber juice retarded ovarian development and was lethal in 27 days.—2-19-45.

LITERATURE CITED

Allman, S. L. 1940. After-effects of feeding Queensland fruitflies on poison baits. Austral. Inst. Agr. Sci. Jour. 6(4): 211–3.

Back, E. A., and C. E. Pemberton. 1917. The melon fly in Hawaii. U.S.D.A. Bul. 491.

Doran, S. C., W. C. Hale and W. M. Hoskins. 1938. The laboratory rearing of flesh flies and the relations between temperature, diet and egg production. JOUR. ECON. ENT. 31(1): 44–51.

Further Studies of Apple Spray Schedule Reduction

PHILIP GARMAN, *Connecticut Agricultural Experiment Station, New Haven*

A total of seven or eight summer sprays is recommended for apples in the 1944 Connecticut Spray Calendar. Successful growers often apply more than this. It is believed that the necessity for almost continual operation of the spray rig needed to carry out such a program reflects on our ability as entomologists. Our failure to devise better sprays—sprays which will remain on foliage and fruit for long periods, sprays which protect without injury to the tree or fruit, sprays which will save labor and machine operating expenses—is nothing to be proud of. After a number of years' work, we have come to the general conclusion that the actual number of sprays *can* be reduced substantially without losing commercial control of the more important pests in Connecticut. To do this, the actual amount of lead arsenate applied in a short schedule should probably be equal to the amount applied in the longer or standard program, *i.e.*, a seven-spray program using 3 pounds per 100 gallons should be about equal to a three-spray program using 7 pounds per 100 gallons, provided stickers are used to hold on the spray. It is also evident that the newer fungicides have advantages over sulfur in the reduced programs. Some of the main arguments for the shorter schedules appear to be: better European red mite control, better maggot control, less fruit russet, less foliage drop, and finally a saving in labor, gasoline and machine depreciation, something that always appeals to the grower.

Considerable laboratory work disclosed the fact that a number of our so-called stickers are of little value, while some of them are actually detrimental. Glass slide tests enabled us to eliminate such materials as soaps, lime and flour, none of which are worth much as stickers in a multiple spray mixture. Experiments along this line included tests with concentrated mixtures, using a settling tower to put the material on the slides evenly. By varying the percentage of sticker, amounts of wash and the amounts of deposit on the slides, we were able to form what appears to be a fairly good estimate of the various stickers. Our greatest difficulty in glass slide tests has been to evaluate materials that flake easily from the leaves but not from glass. Lime is one of these and the difference between slides and leaves is marked. We have seen at least one other mixture which varied in adhesiveness when evaluated by foliage and glass slide experiments.

In the laboratory foliage tests small potted plants such as peach, apple or privet (or shoots therefrom) were sprayed and washed in an improvised washer with meter attached and pressure in the line reduced to 20 pounds. Many visual tests were conducted in this manner, the sprayed portions being always in pairs so that one could be washed and the other held for comparison. As many as five different treatments were handled at one time. Visual tests are, of course, not always accurate, but they serve as a check on the slide tests and with a few exceptions seemed to correspond with them. In similar tests of this kind where observations were considered unreliable, chemical analyses were resorted to. All analyses have been handled by Mr. C. E. Shepard of the Connecticut Agricultural Experiment Station Department of Analytical Chemistry. A series in which deposits of varying size were washed with a constant amount of water are particularly interesting (Table 1). They indicate that some materials wash to approximately the same final deposit no matter how large the deposit is in the beginning. Some combinations such as lead arsenate and lime apparently wash to lower residues the heavier the original deposit (Table 1). When the deposits were very heavy, stickers used in 1944 field tests held two to three times as much as plain lead arsenate with no additions. These same mixtures held on 17 times as much as could be retained with lead arsenate and lime (compare "D," 8 to 9,000 deposit with "B," 11 to 12,000).

FIELD EXPERIMENTS.—Field experiments in 1940 gave such promising results, as regards spray retention and condition of the fruit and foliage at harvest, that the work was continued. In the first mixtures used, it became apparent that fresh aluminum hydroxide was being formed in the spray and that this material was safening both the oil used as a sticker and the

lead arsenate. In later experiments, straight aluminum hydroxide and other gels were used with similar results. Scab control was, of course, not obtained with the first mixtures because they contained no fungicides. With the introduction of organic fungicides, however, we began to get scab control with the reduced schedules. Because the period between sprays is somewhat longer than employed in the standard schedule, one of our greatest problems has been to obtain curculio control equal to standard programs. Experiments prior to 1944 always yielded less curculio control for the short schedules. Tests in 1944 were designed to improve this condition. Figures obtained from harvested fruit counts indicate that we were able for the first time to equal or improve upon the curculio control obtained with standard schedules, tables 2 and 3.

During 1943, we compared a three- with a five-spray schedule in order to determine how well scab could be handled. Results were very gratifying in spite of the wet early part of the season (Table 4). In 1944 we compared a seven-spray with a three-spray program and produced just as good fruit with the shorter one. A series of 3, 6 and 9 pounds of lead arsenate with 0.75, 1.5 and 3 pounds of *Fermate*, together with aluminum gel-white oil sticker, gave interesting results. Insect control was progressively better with increased dosages (Fig. 1). They showed that three sprays with 6 pounds of lead arsenate per 100 gallons were fully equal in curculio control to seven sprays of 3 pounds in the standard schedule. Statistical significance of several comparisons in this series is shown in table 3. From this

Table 1.—Residues remaining on apple foliage after a constant wash in a laboratory rain chamber. Figures are micrograms lead arsenate per 50 square centimeters.

Deposit of Lead Arsenate on Apple Leaves at Start of Experiment	Lead Arsenate Remaining after Wash (A. No Sticker)	Deposit of Lead Arsenate on Apple Leaves at Start of Experiment	Lead Arsenate Remaining after Wash (B. Lime Added)
1– 2000	557	1– 2000	514
2– 3000	1140	4– 5000	406
7– 8000	1270	11–12000	279
14–15000	2487		
	(C. Flotation sulfur bentonite and skim milk added)		(D. *Fermate*[1] bentonite, skim milk and oil added)
1– 2000	723	2– 3000	1928
2– 3000	837	3– 4000	1674
3– 4000	1167	4– 5000	3906
9–10000	5022	8– 9000	5395

(A) Lead arsenate only. Varying amounts of water used to suspend the lead arsenate and also the other formulae, in order to increase the deposits. (B) Lead arsenate and lime, equal parts. (C) Lead arsenate 3 parts, flotation sulfur (dry) 5 parts, bentonite 3 parts, skim milk ½ part. (D) Lead arsenate 3 parts, *Fermate* 2 parts, bentonite 3 parts, skim milk ½ part, oil (100 vis. white mineral) 1 per cent of diluted mixture.
[1] *Fermate*—ferric dimethyldithiocarbamate.

Table 2.—Percentages of sound and curculio marked fruit from Burton's orchard in 1944. Figures are averages of all trees examined. Varieties—Baldwin, McIntosh and Gravenstein.

Treatment	Amounts in 100 Gals.	Per Cent Clean Fruit	Per Cent Curculio	Number of Trees
(1) *Reduced*	3 lbs. lead arsenate 8 oz. *Fermate*[1]	90.94	3.62	14
(2) *Reduced*	6 lbs. lead arsenate 24 oz. *Fermate*[1]	92.88	2.87	19
(3) *Reduced*	9 lbs. lead arsenate 3 lbs. *Fermate*[1]	95.21	1.42	15
(4) *Standard*	3 lbs. lead arsenate 8 lbs. flotation sulfur paste[2]	89.35	3.43	12

[1] Plus aluminum hydroxide gel 3 lbs., white mineral oil ⅔ qts.
[2] No sticker added.

Table 3.—Comparison of the different treatments given in table 2 showing significance of the treatments as computed by statistical methods. Data figured from individual tree comparisons, not directly from table 2.

Treatments Compared	Clean Fruit	Curculio
1 and 4	not significant	not significant
1 and 2	not significant	not significant
1 and 3	significant	significant
2 and 3	significant	significant
2 and 4	significant	not significant
3 and 4	significant	significant

work, we have come to the conclusion that the most practical basic formula for future experiments includes lead arsenate 6 pounds to 100 gallons. *Fermate* 1.5 pounds, aluminum gel or bentonite-skim milk[1] 3 pounds. Soybean oil seemed to be better with the bentonite mixtures than mineral oil, but both were successful. We also compared lead arsenate–*Fermate*-oil mixtures with lead arsenate, *Fermate* and oil to which was added safeners such as bentonite or aluminum gels. There appeared to be some advantage in the use of safeners for preventing leaf drop presumably from the oil, but the mixture was reasonably successful without the safeners. We also tried some plots without oil, using bentonite-skim milk or bentonite-casein alone as the sticker. In these tests results were nearly or quite equal to the experiments in which oil was used, though it is possible that a wetter season might have shown differences.

Table 4.—Scab control with reduced schedules, 1943. Varieties—McIntosh and Rome.

Materials and Amounts per 100 Gallons	McIntosh Per Cent Scab	Rome Per Cent Scab
Lead arsenate 3 lbs. at pink, 6 lbs. at calyx and first cover *Fermate* 0.75 lb. Aluminum hydroxide gel or bentonite, and oil *4-spray reduced schedule*	29.84	5.46
Same with *Fermate* increased to 1.5 lbs. *4-spray reduced schedule*	2.65	1.72
Lead arsenate 3 lbs. Dry flotation sulfur 5 lbs. *6-spray extended schedule*	19.22	6.34

Table 5.—Arsenical residues on fruit at harvest—1944 experiments.

Treatment and Amounts per 100 Gallons	Grains As_2O_3 per Pound of Fruit		
	Gravenstein 8/22	McIntosh 9/9	Baldwin 9/29
(1) *Reduced* 9 lbs. lead arsenate	.032	.022	.019
Last spray June 9	.026	.028	.026
(2) *Reduced* 6 lbs. lead arsenate	.018	.015	.015
Last spray June 9	.018	.020	.016
(3) *Reduced* 3 lbs. lead arsenate	.013	.014	.012
Last spray June 9	.010	.013	.011
(4) *Standard* 3 lbs. lead arsenate	.038	.027	.024
Last spray July 25	.026	.032	.035

U. S. Government tolerance is .025 grains As_2O_3 per pound of fruit.

[1] Bentonite 2.5 pounds, skim milk 0.5 pound to make 3 pounds total.

This year we were particularly interested in determining the spray residues at harvest because of the dry season. Six samples taken from the standard seven-spray plots, half of which were selected for heavy residues, showed five of the six over tolerance. From the plots receiving 9 pounds of lead arsenate in a three-spray schedule, four of the six samples, selected as above, were over tolerance, while from those receiving 6 pounds or less in the reduced programs none were over tolerance, table 5.

CONCLUSIONS.—Results obtained so far make it apparent (1) that stickers may be partly if not completely evaluated by laboratory tests with slides and foliage, (2) that the more successful stickers, including materials such as bentonite-skim milk, aluminum hydroxide gel or aluminum silicate gel plus oil, are eminently successful in reduced programs for light to moderate infestations in insects. Where *Fermate* is the fungicide, disease control is also satisfactory under the same condition —light to moderate infections. They afford much promise for generally reducing the spray program in Connecticut.

RESERVATIONS.—(1) It is not claimed that reduced programs will control severe outbreaks of scab, codling moth, apple maggot or even curculio. Supplementary treatments may be necessary, just as they are with any other program. (2) Also, we do not yet know what the grower will be able to do with our formulae. The special mixtures will be hard to handle and may easily cause the grower to become discouraged. (3) Some of the ingredients will not be easy to obtain and there may be still other reasons for failure of the method. Conservatism regarding reduced programs is therefore still important.—12-16-44.

Solid Baits for Codling Moth

J. R. Eyer, *New Mexico Agricultural Experiment Station, State College*

In 1941, it was observed that a mixture of gum tragacanth, glycerine, and water served as a satisfactory medium in which codling-moth attractants such as alcohols, organic acids, esters, aldehydes, ketones and essential oils could be dispersed and retain their attractiveness over a period of several weeks. Recently investigations have been directed toward developing a solid medium or carrier for these attractants which may be quickly and easily prepared, which hardens satisfactorily on exposure to air, and which does not interact unfavorably with the attractive compounds. Two such mixtures have now been given a sufficient number of tests to establish their usefulness and to justify a description of their composition and use, so that entomologists investigating the broad problem of insect lures can test their applicability in their own particular field of endeavor.

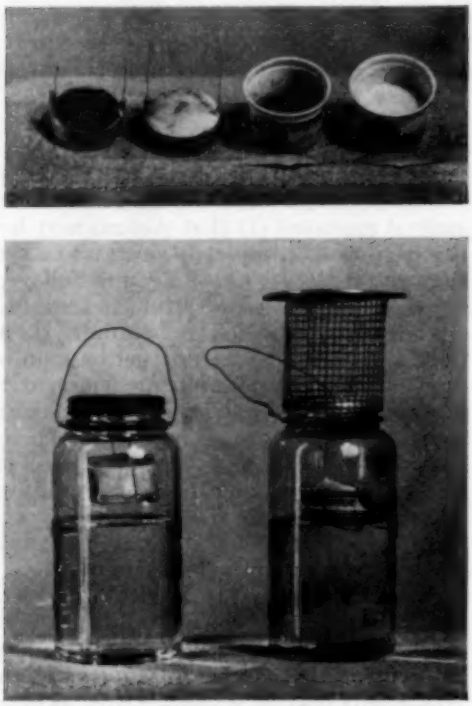


Fig. 1.—Above right—Method of molding solid baits in paper cups; left—same provided with wire supports for suspending to lids of trap jars; Below—Cups filled with bait and suspended in trap jars.

The medium which has been found most satisfactory is a mixture of gum arabic, cane sirup, sawdust, and water. The proportions of the ingredients are varied slightly, depending on whether the attractant with which the medium is to be combined is a liquid or solid and whether it is highly volatile or relatively stable. The formula most commonly used was gum arabic, 250 gms,. cane sirup, 250 cc., water, 500 cc., and sawdust in sufficient amount to give the mixture the consistency of a thin bran mash, i.e., approximately one part of sawdust to four parts of the other combined ingredients. The sirup and water are first mixed together, the gum arabic is then stirred in slowly with a mechanical mixer or egg beater, and the sawdust is added last, using a large spoon or paddle for the final mixing. The attractant may be conveniently added at the same time as the sawdust. The amount and method of combining it with the medium will vary somewhat with its physical nature. Liquids or solids which are readily soluble in cold water were stirred in directly, while those which were insoluble were first dissolved in warm water or ethyl alcohol. Most of the attractants tested were found to be either soluble or readily emulsified and dispersed by vigorous stirring. The amount of attractant to be used is also determined by its nature. In the tests thus far five or ten parts by volume were added. Very few of the attractants commonly used for codling moth were found to react unfavorably with this medium. Oils which are rather viscous such as pine-tar oil may interfere with proper hardening, in which case more sawdust and gum arabic are used. Active organic acids such as glacial acetic may effervesce slightly when first combined with the medium; this can be avoided by adding them after moderate dilution. After the attractant is added the mixture is poured into paper molds. Four-ounce wax paper cups of the type used for the dispensing of ice cream have been found quite satisfactory for this purpose. This type of container when provided with a paper lid permits its being tightly closed

and the bait after hardening can be stored or be transported considerable distances, if desired. For field testing a cup of bait was suspended from the wire cover of the same type of glass canning jar as used for sirup baits, (Fig. 1), and the jars were filled with sufficient water to bring the surface directly beneath the bottom of the cup. During periods of very rainy weather it was found advantageous to suspend the cups upside down or to use a special cover, as shown in the lower right-hand illustration of the figure. During the spring and summer of 1944, this medium was used in combination with such attractants as pine-tar oil, safrole, acetic acid, and valeric acid and tests were made in several orchards in different parts of New Mexico, (Table 1) Tests of a series of organic acids which occur in apple fruit or among the fermentation products of cane sirup are presented in table 2.

A second medium which was found well adapted for use with pine-tar oil, safrole, nicotine sulfate, and some crystalline organic acids was plaster of paris. A thin paste was made by mixing this with water and the attractant was then added. A small amount of sawdust was found to hasten the hardening when the attractant is oily or liberates water of crystallization. The resulting bait was molded in cups in the same manner as the gum arabic-sawdust mixture. This bait becomes quite solid in a short time and the cup may be removed after it has hardened. Active organic acids and some esters and aldehydes were observed to react unfavorably with this medium, but this was overcome by first mixing them with sawdust. Scott & Milan (1943) reported the successful use of this medium with isoamyl salicylate in experiments with tobacco hornworm moths.

A further modification of the above was developed for use with yeast as the attractant. The paper bait cup was half filled with sawdust moistened with 10 per cent sirup solution, and a small amount of bakers yeast was added. This was covered with a thin layer of plaster of paris also mixed with the sirup solution. The resulting yeast culture was found to remain viable for several weeks, and as

Table 1.—Tests of codling-moth attractants as solid baits.

Material	Location and Period of Test								
	Aztec, N. M., 5/29–6/28			Aztec, N. M., 7/30–8/20			State College, N. M., 8/16–9/7		
	Moths Captured	Per cent of Series	Per cent Ratio to Control	Moths Captured	Per cent of Series	Per cent Ratio to Control	Moths Captured	Per cent of Series	Per cent Ratio to Control
Pine tar, 10% in plaster of paris	30	8.02	28.85	78	24.07	88.64	22	7.94	20.95
Safrole, 10% in plaster of paris	78	20.86	75.00	60	18.52	68.18	72	25.99	68.57
Acetic acid, 5% in gum arabic and sawdust	12	3.21	11.54	2[1]	0.62	2.27	18	6.50	17.14
Valeric acid, 5% in gum arabic and sawdust	24	6.42	23.08	6[1]	1.85	6.82	23	8.30	21.90
Yeast with molasses, sawdust, and plaster of paris	126	33.69	121.15	78	24.07	88.64	19	6.86	18.10
Ethyl oxyhydrate, 10% in sawdust and plaster of paris	Not Represented			12	3.70	13.64	18	6.50	17.14
Control: cane sirup, 10% in water	104	27.81	100.00	88	27.16	100.00	105	37.91	100.00

[1] Plaster of paris and sawdust used as carrier.

Table 2.—Tests of organic acids as solid baits.

Bait Material	Location and Period of Test					
	State College, July 29–August 5			State College, August 20–September 7		
	Moths Caught	Per cent of Series Total	Per cent Ratio to Control	Moths Caught	Per cent of Series Total	Per cent Ratio to Control
Acetic acid, 5% in gum arabic and sawdust	9	7.83	50.00	12	6.98	31.58
Aceto-acetic acid, 5% in gum arabic and sawdust	7	6.09	38.88	8	4.65	21.05
Phenyl acetic acid, 5% in plaster of paris and sawdust	14	12.17	77.77	34	19.77	89.47
A-amino acetic acid, 10% in gum arabic and sawdust	13	11.30	72.22	Not represented		
Valeric acid, 5% in gum arabic and sawdust	4	3.48	22.22	16	9.30	42.11
Pyroligneous acid, 5% in gum arabic and sawdust	6	5.22	33.33	10	5.81	26.32
Pyruvic acid, 10% in gum arabic and sawdust	20	17.39	111.11	42	24.42	110.53
Tannic acid, 10% in gum arabic and sawdust	8	6.96	44.44	Not represented		
Succinic acid, 10% in gum arabic and sawdust	6	5.22	33.33	8	4.65	21.05
Malic acid, 10% in gum arabic and sawdust	10	8.70	55.55	4	2.33	10.53
Control: cane sirup, 10% in water	18	15.65	100.00	38	22.09	100.00

indicated in the table 1 it compared favorably in attractiveness with safrole and pine tar.

Conclusion:—Although none of the attractants thus far tested consistently excelled the ferementing cane sirup bait, certain ones, *i.e.*, safrole, phenyl acetic acid, pyruvic acid, and yeast, appear promising, and were observed to possess the following advantages:

1. Solid baits containing codling-moth attractants of the essential oil ond organic acid types are highly selective and catch very few insects other than this species. Muscoid flies, scarabaeid beetles, and miscellaneous Lepidoptera which frequent sirup traps and interfere with codling-moth recording are practically absent. 2. Trap jars provided with solid baits are filled with water alone and consequently are cleaner and more easily observed and serviced. 3. Solid baits may be prepared in advance of the flight periods of each generation and conveniently stored in a cool place, to be used in the forecasting of spray schedules, when desired. 4. When given proper protection, these baits are not adversely affected by rains or excessively high temperatures, as are sirup baits.—1-4-44.

Literature Cited

Eyer, J. R., and J. T. Medler. 1941. Attractiveness to codling-moth of substances related to those elaborated by heterofermentative bacteria in baits. Jour. Econ. Ent. 33(6): 933–40.

Scott, L. B., and Joe Milam. 1943. Isoamyl salicylate as an attractant for hornworm moths. Jour. Econ. Ent. 36(5): 712–5.

Control of Codling Moth on Walnuts: Progress Report

A. E. Michelbacher,[1] *University of California, Berkeley*

The codling moth, *Carpocapsa pomonella* (L.), has become one of the most serious pests attacking walnuts in California. Much of the early work on this insect was conducted by Quayle (1926). Among the other early work that might be mentioned is that of Smith (1929). Important later investigations were conducted by, and principally under the supervision of, A. M. Boyce. The results of these investigations have been reported in papers by Boyce & Stanton (1933), Stanton (1933), Braucher & Boyce (1934), Boyce (1935), and Boyce & Bartlett (1941). The last two papers sum up much of the latest information concerning the ecology and control of the pest. Most of the studies of the codling moth were conducted in southern California. Work at Linden in northern California was first undertaken by Boyce and his associates, but because of the great distance from Riverside, this investigational work was turned over to the entomological group at Berkeley. This early work of Boyce indicated that information on the timing of spray applications needed further investigation. The information here reported covers investigations conducted at Linden on the Payne variety of walnut, during the years 1942 to 1944 inclusive.

Investigations of 1942.—In 1942 the following spray programs were studied:

1. No spray
2. Sprayed once May 29.
3. Sprayed twice May 5 and 29.
4. Sprayed twice May 29 and June 30.
5. Sprayed three times, May 29, June 30, and July 29.

The composition of the spray per 100 gallons consisted of 4 pounds of basic lead arsenate, 0.33 pound of wetting agent, and 0.33 gallon neutral medium soluble oil. The rate of application ranged between 40 and 50 gallons per tree for each treatment. A Bean sprayer equipped with a tower was used for making the applications, and the sprays were applied at a pressure of 600 pounds. The experiment consisted of single tree plots replicated 5 times in a latin square. The degree of infestation in the harvested crop was as follows:

1. No spray.....24.07 per cent
2. Sprayed once May 29.....11.46 per cent
3. Sprayed twice May 5 and 29... 4.11 per cent
4. Sprayed twice May 29 and June 30..... 7.14 per cent
5. Sprayed three times, May 29, June 30 and July 29..... 6.40 per cent

From the above it is evident that the treatment that gave best control was where sprays were applied on May 5 and May 29. From early in the season it was apparent that this treatment held an advantage over the others. The first spray was applied early enough to control the first brood and the later spray protected the crop from the second. The trend of infestation was followed from the beginning of the season. This was done by examining 40 nuts per tree on each survey, although in 1943 and 1944 this number was increased to 80. The nuts examined were on the lower portion of the trees, and they were not picked unless it was necessary to do so in order to determine for a certainty whether or not they were infested. It was found that worms started entering nuts early in May and that the infestation by the first brood of codling moth larvae built up very rapidly. On June 2, 18 per cent of the nuts on the check trees were infested. This indicated that if spraying is delayed until late May or early June, it is applied too late to give satisfactory control of the first brood. Since this is the time that most growers applied their sprays, it was obvious that they were suffering a serious loss. However, if the sprays were properly applied, they resulted in the control of the second brood. If this occurred, the control obtained appeared good because early infested nuts usually drop prematurely and thus are not involved in the harvested crop.

A careful check was made of the nuts that dropped from the trees. It was noted that the two main causes for the dropping was infestation by codling moth and

[1] Clark Swanson, an Assistant Farm Advisor in San Joaquin County, gave his full cooperation in the conduct of this investigation. He aided in every phase of the work and deserves full credit for the successful planning of the experiments and the interpretation of the results obtained.

Thanks are due to C. C. Anderson and Ralph Bishop who made it possible for us to conduct the investigations here reported. We also wish to thank A. M. Boyce, G. F. MacLeod, A. D. Borden, E. G. Scott, G. L. Smith and Ray F. Smith for aid rendered in planning and carrying out the investigation.

bacterial blight of walnuts. Nearly all the nuts were either infested with caterpillars or infected with blight. During June and July most of the drops in the check plots were infested, but from then on to harvest infested nuts made up a smaller proportion of the drops. It was also found that there was a decrease in the amount of drops due to caterpillars as the effectiveness of the spray treatments increased. During the growing season the

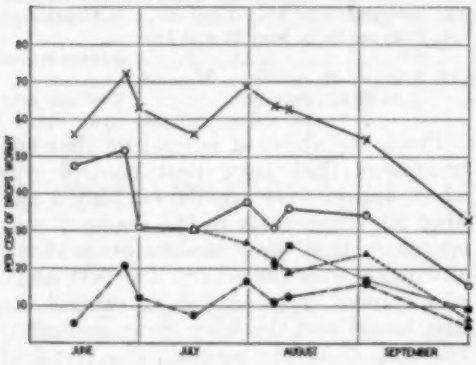


FIG. 1.—Trend of infestation in dropped nuts X, check; Circles, sprayed May 29; Triangles, sprayed May 29 and June 30; Squares, sprayed May 29, June 30 and July 29; and Dots, sprayed May 5 and May 29.

dropped nuts for the different treatments were gathered on nine occasions. The per cent of infested nuts in each of these collections was determined and is plotted in figure 1, which clearly shows that the infestation was highest in the checks and lowest where the trees were sprayed on May 5 and again on May 29.

INVESTIGATIONS OF 1943.—Because most satisfactory control in 1942 was obtained with two early sprays, the 1943 investigation was designed to see if this could be substantiated. Also some investigational work with standard lead arsenate was started. The following spray programs were studied:

1. No spray
2. Sprayed once May 7
3. Sprayed once May 17
4. Sprayed once May 28
5. Sprayed twice May 7 and May 28

(basic lead arsenate)

6. Sprayed once May 17 (Standard lead arsenate with safener)

The composition of the basic lead arsenate sprays was the same as in 1942, except that the amount of spreader used with some of the later sprays was reduced to 3 ounces to the 100 gallons. The composition of the spray per 100 gallons, where the standard lead arsenate was used, consisted of 3 pounds of standard lead arsenate, 1 pound of *Delmo Z* (a commercial basic zinc-sulfate product which is used as a safener for standard lead arsenate and which contains 50 per cent zinc expressed as metallic), 0.33 pound of spreader and 0.33 gallon of a neutral medium soluble oil. In all cases approximately 45 gallons of spray were applied per tree per application. The degree of infestation in the harvested crop was as follows:

1. No spray	18.73 per cent
2. Sprayed once May 7	9.64 per cent
3. Sprayed once May 17	5.90 per cent
4. Sprayed once May 28	7.82 per cent
5. Sprayed twice May 7 and May 28	4.42 per cent
6. Sprayed once May 17 (Standard lead)	4.00 per cent

From the above it is seen that where basic lead arsenate was used fewest infested nuts in the harvested crop occurred where the trees were sprayed twice, once on May 7 and a second time on May 28. This, of course, substantiated the work of the preceding year. The single standard lead arsenate treatment applied May 17 gave slightly fewer infested nuts but the difference was extremely small and probably not significant.

As in 1942, the trend of infestation for the different treatments was determined by making tree surveys. In all, 10 surveys were made and the results obtained are plotted in figure 2 along with bars to the right that indicate the degree of infestation found in the harvested crop. Some variation exists between the degree of infestation in the final tree count and that found in the harvested nuts for the different treatments. In some cases the variation is slight, and the widest spread occurred in the check. Most of the variation can be accounted for by the methods used in making the counts. In the tree surveys all nuts attacked by caterpillars were considered as infested, while in the harvested crop only those nuts in which the caterpillars had gotten inside the shell were classed as infested. Particularly in the harvested nuts from the check trees there were many where the caterpillars had only fed on the husks. The shells of

such nuts were stained but the meats were usually in excellent condition. This class of nut in the check plots probably made up 20 to 25 per cent of the nuts that had been attacked by caterpillars and had they been included with the infested nuts, the per cent of the latter in the harvested crop would have closely paralleled that found on the last tree survey. To a lesser extent this was also the case with the trees that were sprayed once on May 7.

On May 7, at the time the first spray was applied, 2 per cent of the nuts were infested, and the peak of infestation by the first brood was reached about the end of May. Infestation by second brood worms did not occur until after the middle of July.

Caterpillar infestation in the nuts that dropped was carefully followed. There was much less infection of walnut blight than in 1942, and as a result most of the drop early in the season was due to nuts infested with caterpillars. The number of drops as determined by counting nuts in a limited area under each tree was heaviest in the check and least in the most effective treatments. In the checks there was a very heavy drop from about the first of June to about the middle of July. Nearly all of these drops were infested and for some surveys nearly 100 per cent had been attacked by caterpillars.

INVESTIGATIONS OF 1944.—The 1944 investigations were designed to obtain further evidence on the value of an early spray to control the first brood of codling moth, and to gain more information on the timing of the second spray. Because standard lead arsenate looked so promising in 1943 and caused no burn or other visible injury that year, a further comparison of this material with basic lead arsenate was made. Experiments with DDT were conducted also, but a summary of these tests will later be considered separately.

The spray programs tested are shown in figure 3 in the following summary:

1. No spray
2. Sprayed once May 1
3. Sprayed once May 29
4. Sprayed twice May 1 and 18
5. Sprayed twice May 1 and 29
6. Sprayed twice May 1 and June 26
(Nos. 2 to 6 sprayed with basic lead arsenates)
7. Sprayed twice May 1 and 29 (Standard lead arsenate with safener)

The composition of the basic lead arsenate spray was the same as used in previous years except that the amount of wetting agent was reduced to 2.67 ounces to the 100 gallons of spray. The standard lead arsenate spray was the same as used in 1943 except that 0.5 pint of a liquid spreader and sticker was used to the 100 gallons of spray instead of 0.33 pound of a dry spreader Information concerning dates of application, size of nuts at time of

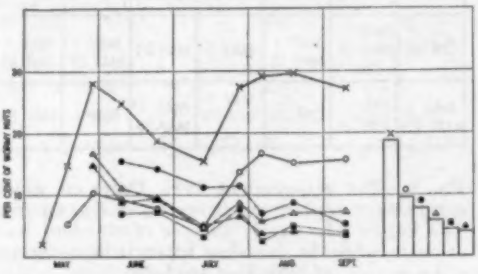


FIG. 2.—Trend of infestation during maturing of crop and infestation in harvested crop for the 1943 season. X, check; Circles, sprayed May 7 with basic lead arsenate; Dots, sprayed May 28 with basic lead arsenate; Open triangles, sprayed May 17 with basic lead arsenate; Solid squares, sprayed May 7 and 28 with basic lead arsenate; and Solid triangles, sprayed May 17 with standard lead arsenate.

spraying, method of application, and gallons of spray applied per tree is given in table 1. The degree of infestation in the harvested crop for the different treatments is given in table 2. The basic lead arsenate treatment that gave best control

Table 1.—Information on application of sprays.

DATE APPLIED	TYPE OF SPRAYER[1]	APPROXIMATE NUMBER OF GALLONS APPLIED PER TREE	RANGE IN SIZE OF NUTS (GREATEST CROSS SECTION DIAMETER IN INCHES)
May 1	20 foot tower 3 gun, manual	70	0.25–0.5
May 18	20 foot tower 3 gun, manual	55	0.5 –1
May 29	25 foot tower automatic	60	1–1.25
June 26	15 foot tower automatic	60	1–1.5

[1] All of *Bean* manufacture.

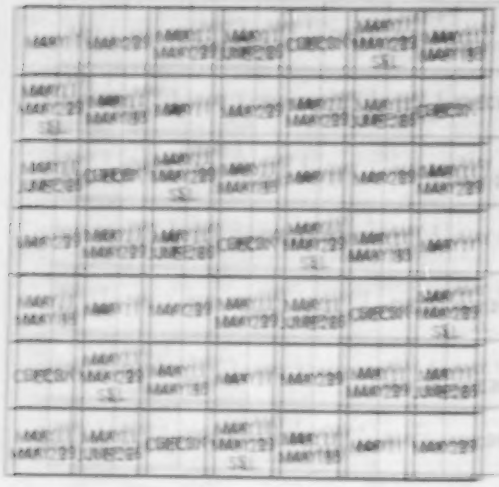


FIG. 33.—Plot arrangement, 1944. Dates on which sprays were applied are indicated in the squares. The letters SL signify the use of standard lead arsenate, while the absence of letters indicates the use of basic lead arsenate.

was that in which two sprays were applied, one on May 11 and the second on May 18. This treatment gave slightly better control than either of the other two double spray basic lead arsenate treatments but not quite as good control as the two spray standard lead arsenate treatments. The difference between the latter, although small, is statistically significant. If the standard lead arsenate treatment is contrasted with the comparable basic lead arsenate treatment, the difference in the degree of infestation is markedly significant.

The trends of infestation for the different treatments were determined by making 10 tree surveys. The results of these surveys are plotted in figure 4, together with the degree of infestation in the harvested crop which is represented at the right in the figure by bars.

TABLE 22.—Comparison of several spray treatments in controlling codling moth in the harvested walnut crop, 1944.

Treatment and Dates of Application	Percentage Harvested		Entire Crop	
	Good	Wormy	Percentage Wormy	Grams Nuts Per Tree
Check	31.02	51.57	61.69	91.99
Basic: May 11	32.84	11.11	7.31	88.22
Basic: May 20	44.68	21.01	7.02	87.00
Basic: May 11 and 18	91.28	0.43	0.62	89.30
Basic: May 11 and 20	71.02	0.68	0.72	87.89
Basic: May 11 and June 28	11.67	0.36	0.89	88.57
Standard: May 11 and 20	91.36	0.48	0.69	89.73

[1] Not removed with dirt by sterilization.
[2] Not attacked by caterpillars but wormy nuts were found in orchard to other causes.

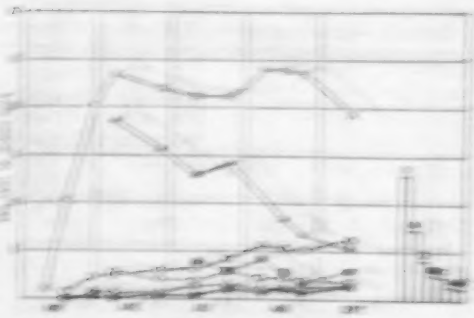


FIG. 4.—Trend of infestation during the maturing of the crop and infestation in the harvested crop for the 1944 season. X, check (Circles, sprayed May 11 with basic lead arsenate; Solid triangles, sprayed May 20 with basic lead arsenate; Open triangles, sprayed May 11 and 18 with basic lead arsenate; Open squares, sprayed May 11 and 20 with basic lead arsenate; Solid squares, sprayed May 11 and June 28 with basic lead arsenate; and Dots, sprayed May 11 and 20 with standard lead arsenate.

Due to the cold spring, the first brood of larvae was later in making its appearance than in any year since our investigations were started. No larvae were encountered attacking nuts until the 8th of May. From this time until the first of June there was a rapid build up in the infestation. Infestation by the second brood did not become apparent until about the middle of July.

Infestation in the nuts that dropped was carefully followed. There was very little bacterial blight of walnuts early in the season and as a result most of the drop was due to the codling moth. From about June 7 to June 26 there was a very heavy drop of caterpillar infested nuts. The ground under the check and the trees sprayed once on May 20 was covered in

contrast to the effective treatments where relatively few nuts were on the ground. The nuts were collected June 26 and the results are summarized in table 3. From the table it is evident that the trees sprayed with standard lead arsenate had the fewest dropped nuts, and that the trees with the next fewest was the basic lead arsenate treatment where sprays were applied on May 1 and May 18. It should also be noted that a smaller percentage of the dropped nuts were infested in the more effective treatments than in the check on less effective treatments.

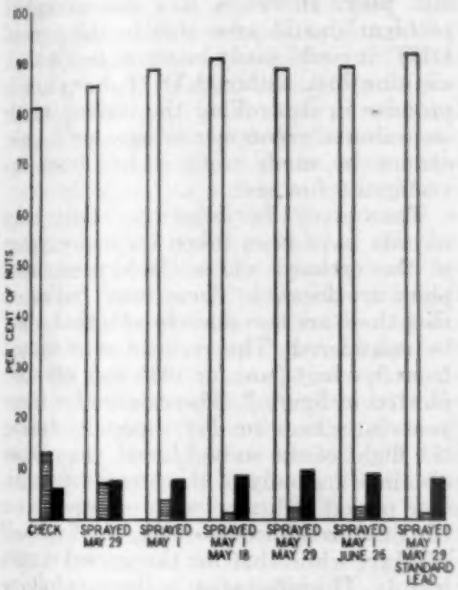


FIG. 5.—Per cent of harvested nuts classified as good, infested and culls other than infested. Open bar, good; Horizontal hatched bars, infested; Solid bar, culls other than infested.

Figure 5 shows the number of good nuts, infested nuts and culls other than infested that was obtained in the harvested crop from the different treatments. This clearly illustrates the relative effectiveness of the various spray treatments in reducing the number of infested nuts in the harvested crop, but it does not show to what degree the nut crop was protected by the treatments. Early infested nuts usually fall prematurely and thus are not registered in the harvested crop. The effectiveness of treatment is best shown in figure 6 where total good nuts, infested nuts and culls other than infested in the harvested crop are plotted.

Table 3.—Effect of treatment on number of nuts dropped, and percentage of dropped nuts infested, June 26, 1944.

TYPE OF LEAD ARSENATE AND DATE OF APPLICATION	DROPPED NUTS PER TREE AVERAGE	DROPPED NUTS INFESTED PER CENT
Check	392	93
Basic May 1	82	75
Basic May 29	461	97
Basic May 1 and 18	50	71
Basic May 1 and 29	91	84
Basic May 1 and June 26	71	76
Standard May 1 and 29	32	55

This shows that the yield of good nuts for the check trees falls far short of that of any of the spray treatments, and illustrates the loss a grower suffers if control is neglected. Not only is the

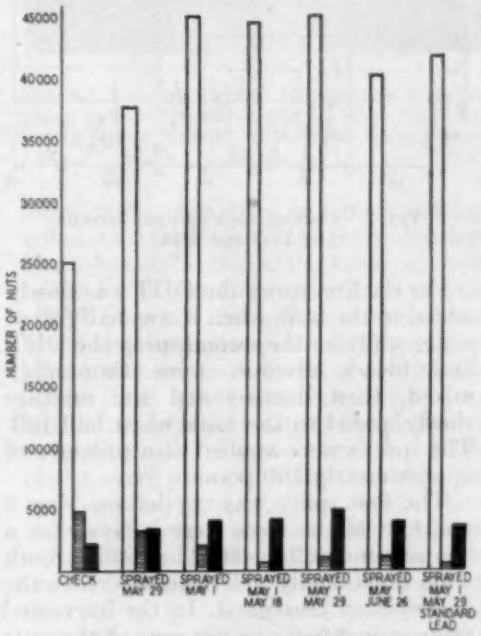


FIG. 6.—Total harvested nuts from each treatment classified as good, infested, and culls other than infested. Open bar, good; Horizontal hatched bar, infested; Solid bar, culls other than infested nuts.

amount of good nuts greatly reduced, but there is also the serious problem of separating out the infested nuts from the good nuts.

INVESTIGATIONS WITH DDT.—Only a very brief summary of this work will be given. One and two spray applications were compared. The DDT used was obtained from the Geigy Company, and the composition of the first spray was as follows:

20 per cent DDT with wetting agent	5 pounds
Water	100 gallons

For the second spray the composition was:

20 per cent DDT without wetting agent	5 pounds
Blood albumin	4 ounces
Water	100 gallons

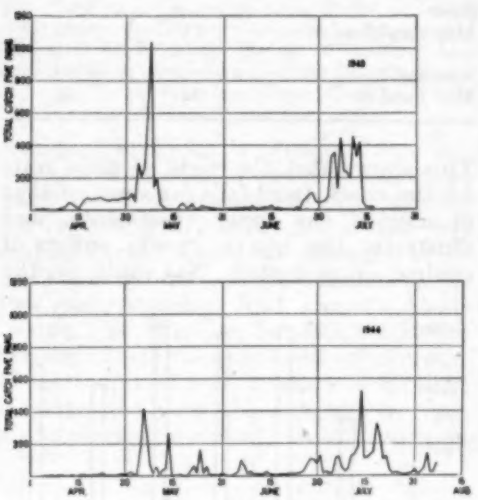


FIG. 7.—Codling moth bait pan records for 1943 and 1944.

For the first spray the DDT was slowly added to the tank when it was half full of water while for the second spray the DDT and blood albumin were thoroughly mixed, then slurried and the mixture slowly added to the tank when half full. The sprays were applied at a pressure of approximately 500 pounds.

The first spray was applied on May 9 and half of the trees were sprayed for a second time on June 26. The codling moth was exceptionally well controlled with the single spray treatment. In the harvested crop, only 0.9 of one per cent of the nuts were infested. Where two sprays were applied, no infested nuts were found in the harvested crop, while the degree of infestation for the check trees was 18.63 per cent.

It was noted that the DDT sprays were effective in killing the walnut aphid but the aphid predators were also killed. Observations made seemed to indicate that the spray remained effective against the predators for a longer period than it did against the aphid. As a result, the aphids apparently were able to reestablish themselves in the trees some little time ahead of the predators. This allowed them to build up in rather destructive numbers before the controlling influence of their predators could come into play. However, if a serious aphid problem should arise due to the use of DDT, it could easily be controlled with a nicotine dust. Although DDT shows much promise in controlling the codling moth on walnuts, recommendations for its use cannot be made until it has been investigated further.

TRENDS OF INFESTATION.—Bait trap records have been taken for many years in the orchard where the experimental plots are located. These have indicated that there are two main broods that must be considered. The records as obtained from five bait pans for 1943 and 1944 are plotted in figure 7. The catches for these years have been smaller, especially during the flight of the second brood, than those obtained in many of the preceding years. The period of heavy moth emergence for the first brood occurs during the first half of May, while that for the second occurs in July. The infestation in the nuts follows the moth flights rather closely although, as would be expected, the peak of infestation in the nuts lags behind the peaks of moth emergence. The correlation which exists between moth catches and caterpillar infestation is clearly shown if the trend of worm infestation for the checks in figures 2 and 4 is compared with the respective bait pan moth catches as plotted in figure 7. It is seen that the peak of caterpillar infestation lags from three to four weeks behind the principal periods of moth emergence.

Careful examination of nuts has shown that caterpillars do not begin to infest nuts until about the first of May. In 1942 such surveys were undertaken too late in the season to give accurate information as to the time that caterpillars first started to enter nuts. In 1943 it was found

that about 2 per cent of the nuts were infested on May 7. Most of these caterpillars were very small and did not appear to be more than a day or two old. Surveys in 1944 did not reveal any evidence of caterpillars entering nuts until May 9. At this time newly hatched caterpillars were observed in nuts. Since the spring of 1944 was cold and backward it is believed that May 9 represents about the latest date that first brood caterpillars would start entering nuts in any year. In most years first entries can be expected to occur about the first of May. Nearly all worms of the first brood enter the nuts at the blossom end. The degree to which these caterpillars had developed by May 17 in 1943 is well illustrated in figure 8. Most of these early infested nuts either drop or dry up on the trees. It is these nuts that constitute the heavy drop that occurs in June. The number of drops exceeds the rate of infestation and as a result there is a dip in the number of infested nuts on the trees between the peaks of the first and second broods. The dip may be rather marked as it was in 1943. The degree to which this occurred is seen in the trend of infestation for the check plots in figure 2. As the season advances there is more of a tendency for the caterpillars to enter the sides and base of the nuts, although many still enter through the blossom end. This occurs even after the nuts in clusters touch. About the base of clusters there may be much caterpillar activity but little evidence of caterpillar entry.

Second brood caterpillars make their appearance in July and most of these penetrate the nuts at the side or stem end, although some still go through the blossom end. Probably more second brood caterpillars penetrate through the stem end than at any other point, and entry occurs most frequently at the base of clusters. By the middle of September nuts have reached maturity and most of the caterpillars found in them are also reaching maturity.

WORM INFESTATION AND BACTERIAL BLIGHT.—There is some evidence that caterpillars of the first brood may make portals of entry for the causal organism of bacterial blight of walnuts. This point still remains to be proven, and until more evidence is obtained to substantiate this, no positive statement can be made. On the other hand, with the first brood, no evidence has been found that would indicate that walnut blight favors caterpillar infestation. It has already been pointed out that most caterpillars of the first brood enter nuts at the blossom end, and in making tree surveys it appeared that caterpillars showed no preference as to the nuts they entered.

Later in the season, and particularly with the second brood, there is considerable evidence which indicates that caterpillars enter injured nuts more freely than they do normal nuts. They appear to show a preference for injured nuts, and it seems to make little difference if the injuries were caused by walnut blight or by some mechanical means. Apparently, codling moth larvae can penetrate young nuts more easily than they can more mature nuts. As the husks and shells harden, blemishes or breaks in the husks make it easier for the young caterpillars to gain entry. Thus the caterpillars of the second brood have a tendency to infest nuts that would mature as culls. As a result culls other than caterpillar infested in the harvested crop decrease as the degree of caterpillar infested nuts increase. In two of the three years that this investigation has been under way, the checks have shown the fewest non-caterpillar infested culls. This is shown in table 2, the 1944 harvest where it can be seen at a glance that there are fewer culls other than caterpillar infested in the check as compared to the spray treatments.

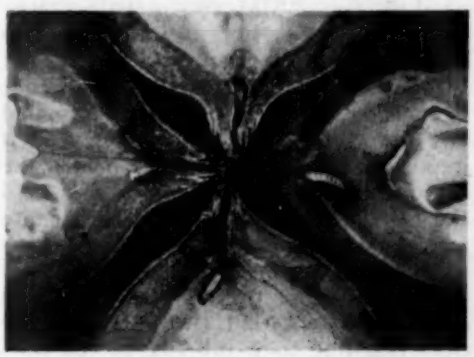


FIG. 8.—Nuts cut through blossom and revealing young caterpillars and degree to which they had penetrated on May 17, 1943. (Two times natural size.)

CONCLUSIONS.—In the 3 years that our investigation has been under way at

Linden it has been found that the seasonal trend of codling moth infestation in the Payne variety of walnuts has followed a rather definite pattern. There are two broods of larvae that must be controlled. The first starts making its appearance about the first of May and the second appears in July. Two sprays are necessary to give most satisfactory control. The proper timing of the first spray is most important, because once started, the infestation by the first brood builds up very rapidly. The spray should be applied as near to the first of May as possible. The period over which it can most satisfactorily be applied ranges from about April 25 to May 5. If delayed until the middle of May over 10 per cent of the nuts may be infested before it is applied and if delayed until the end of May 20 per cent or more of the nuts are likely to be infested before it is applied. The timing of the second spray is not nearly as important as is that of the first. It can apparently be applied any time from May 18 to June 26. It is important that it be applied before the beginning of the second brood. In 1944 the best results with basic lead arsenate were obtained where the first spray was applied on May 1 and the second on May 18. This treatment gave very good control despite the fact that the nuts were far from reaching their full size at the time the second spray was applied. A single early spray cannot be counted on to give satisfactory control of the second brood. However, in 1944 a single basic lead arsenate spray applied May 1 gave surprisingly good control for the entire season. A rather small second brood was probably the reason for this treatment showing up better than expected. Spray properly applied in late May will give good control of the second brood of codling moth, although a serious loss results from a heavy infestation by the first brood. Because early infested nuts drop prematurely or dry up on the trees they do not show up in the harvested crop. Thus the control obtained with a single late spray appears better than it actually is if it is based only upon the infested nuts found in the harvested crop. The only accurate way to determine the effectiveness of treatments is to compare total yields of good nuts.

Standard lead arsenate used in conjunction with the safener *Delvo Z* has given very satisfactory control. The combination has been used for two seasons and it has given slightly better control of caterpillars than comparable basic lead arsenate treatments. No tree injury whatsoever has been detected thus far, and the material certainly recommends itself for further testing. It is certainly more effective against the codling moth than is basic lead, and if further work proves that it is safe to use under all conditions it should find wide use in the codling moth spray program.

DDT proved very promising in the 1944 season's work. It gave exceptionally good control of the codling moth. Its use resulted in a rather serious walnut aphid problem which, however, was taken care of by dusting with a nicotine dust. Because it appeared so effective in worm control, DDT will be used experimentally on a large scale.

One of the most critical considerations in mixing sprays is determining how much wetting agent should be used. This is particularly true with basic lead arsenate. Because of our present lack of knowledge on the subject we believe it is best to advise growers to follow the recommendations made by the manufacturer of the brand of lead arsenate they plan to use.

How far our findings in the Linden area can be applied to other walnut producing sections of northern California still remains to be determined. In the Sacramento Valley serious losses due to codling moth were reported. In 1944 experimental work in that area was undertaken in a Payne orchard near Live Oak. Basic lead arsenate was tested and the experiment was designed to see if the satisfactory treatment in the Linden area would also prove effective there. A serious caterpillar infestation developed, and poor control was obtained. There was a marked build up in the infestation late in the season. Investigation showed that this infestation was caused principally by the Catalina cherry moth, *Melissopus latiferreanus*, and not the codling moth.

SUMMARY.—In the Linden area the codling moth is the most serious insect pest of walnuts. There are two broods that must be controlled. Caterpillars of the first brood make their appearance in May while those of the second make their first appearance in July. For most satisfactory control two spray applications are

necessary. The timing of the first is of most importance because of the rapid build up of the first brood of caterpillars. For best results the first spray should be applied about the first of May. The second spray can be applied anytime from about May 18 to about the end of June. Standard lead arsenate with a safener was found to be more effective than basic lead arsenate. It has been used for two years without causing any visible injury to the trees, but further investigation is needed before it can safely be recommended for general field use. Tests with DDT in 1944 showed much promise, and exceptionally good control of codling moth was obtained.

Most first brood caterpillars enter the nuts at the blossom end, while second brood worms enter the nuts mostly through the side or stem end. Nuts infested early in the season either drop prematurely or dry up on the trees.

Bacterial blight of walnuts or other injuries does not appear to be associated with worm infestation early in the season. Later in the season such injuries apparently aid the caterpillars in gaining entry into the nuts and as a result the number of culls other than caterpillar infested in the harvested crop is likely to decrease as the caterpillar infestation increases.

LITERATURE CITED

Boyce, A. M. 1935. The codling moth in Persian walnuts. JOUR. ECON. ENT: 28(6): 864–73.

Boyce, A. M., and B. B. Bartlett. 1941. Control of the codling moth. Diamond Walnut News. 23(3): 4–7.

Boyce, A. M., and W. R. Stanton. 1933. Application—an important factor in codling moth control. Diamond Walnut News. 15(2): 3–4.

Braucher, O. L., and A. M. Boyce. 1934. Developments in codling moth control. Diamond Walnut News. 17(2): 4, 8.

Quayle, H. J. 1926. The codling moth in walnuts. California Agr. Expt. Sta. Bul. 402.

Smith, R. H. 1929. Additional information on controlling codling moth by spraying and dusting. Diamond Walnut News. 11(1): 8–9.

Stanton, W. R. 1933. The value of tree bands in relation to spraying. Diamond Walnut News. 15(2): 5.

Insect Pests of Cultivated Goldenrod

C. H. HOFFMANN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During 1943 the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, assisted the Department agencies cooperating in the Emergency Rubber Project by surveying cultivated goldenrod plantings in order to appraise insect damage and to suggest control measures where necessary. The plantings involved approximately 650 acres in five southern states and were made to produce a supply of rubber for technical experimentation. Twelve selections of a species of goldenrod, *Solidago leavenworthii*, were grown under varying conditions. Unless otherwise designated, the selections mentioned in the present paper refer to this species.

The writer inspected the large plantings in the vicinities of Waynesboro and Savannah, Ga., and also the test plantings near Orangeburg, Florence, and Clemson, S. C., late in May, for evidence of insect attack. In August the aforementioned plantings were reinspected, and an initial examination was made of indicator plantings established near Tifton and Cairo, Ga., Meridian, Miss., Andalusia, Ala., and Alexandria and Houma, La. Specimens of insect associated with goldenrod were collected at the different localities either for preservation or for rearing, and later were identified.[1] Some of the common pests could not be determined on the basis of immature stages, so an effort was made to rear them. Many of these rearings failed to produce adults, however, because the earlier stages were heavily parasitized. Little information is available on the pests of cultivated goldenrod. The following notes are presented to fill this gap and to serve as a basis for more extensive

[1] Grateful acknowledgment is made to the specialists of the Bureau's Division of Insect Identification for determining specimens taken on the surveys.

future studies. Injurious species are treated under the part of the plant attacked. Forms collected on goldenrod and which may be potential pests are considered separately.

INSECTS INJURIOUS TO THE TERMINAL GROWTH.—Several stages of an undetermined species of *Thrips* were observed feeding on goldenrod in many of the fields in Georgia and South Carolina. The insects were feeding in the axils of the unfurling leaves of the terminal growth, sometimes causing it to become stunted. The leaves of infested plants were either crinkled or distorted, etiolated, and had a sheen not present on healthy plants. There was sometimes also a die-back of the outer leaves and necrotic areas. The unfolding of the inner leaves of the terminal usually revealed russeted areas and streaks of discoloration, particularly along the margins, where the tissue was dying as a result of the feeding injuries.

Greatest damage occurred late in May on plants ranging in height from 18 to 24 inches in the plantings at Savannah. Plans were made to control the infestation, but the sudden diminution of the population made this unnecessary. Selection 6S-30 was conspicuously affected, whereas adjoining rows of selection 3S-79 were lightly infested and showed little damage. A comparatively small number of plants in the extensive Waynesboro plantings were attacked by thrips. At Clemson, in August, noticeable damage also occurred in experimental blocks of *Solidago altissima* (selections Savannah River and 3S-452).

The larva of an olethreutid moth, *Thiodia* sp., injured the terminal growth and the uppermost leaves by webbing them together and by feeding upon them from a concealed position. Usually the terminal became crooked and the leaves distorted and curled. These leaf-roller larvae ordinarily caused a stunting of the terminal growth but sometimes destroyed it. Occasionally, in many-branched plants several branches were infested. The species was prevalent in August in localized areas of fields near Savannah, Waynesboro, Meridian, and Florence. Infestation counts of 50 to 100 plants at Florence showed that 38 per cent of the 6S-30 plants were infested, whereas selections 3S-91, 3S-40, 3S-79, and 5S-59 were unattacked. Observations and counts at other localities also indicated that selection 6S-30 was preferred by this leaf roller. The damage caused by the larvae did not appear to be important. Two larvae collected on May 29 at Savannah pupated on June 19 and June 30 and moths emerged 9 and 15 days later, respectively. These adults and another reared specimen were identified as *Thiodia* sp., possibly a variety of *umbrastriana* (Kearf.).

A few goldenrod plants were attacked by corn earworms, *Heliothis armigera* (Hbn.), late in May and early in June at Florence and Waynesboro. These small, variegated larvae were found feeding on the terminal buds of plants less than 12 inches in height.

One very active larva of a tortricid moth, *Platynota* sp., was taken in August at Cairo. It had spun a light web encompassing the terminal leaves of a shoot and had practically severed the tip.

Small galls, each of which contained several itonidid larvae, were collected from terminal buds on May 25 at Waynesboro. The injury produced was inconsequential.

INSECTS THAT DAMAGE THE LEAVES.—The larvae of a fly, *Agromyza* sp., probably a new species, caused irregularly-shaped mines in goldenrod leaves. Usually only one or two leaves of a plant were infested. The small amount of leaf tissue destroyed and the light infestations found suggest that it caused little damage to the 1943 plantings. Leaf injuries typical of this species were observed at Clemson, Waynesboro, Savannah, Meridian, and Andalusia. The miner attack was more prevalent in May than in August. Most of the puparia removed from mines collected at Savannah on May 28 produced parasites on June 5. These were all new species belonging to the following genera and families: *Opius* (Braconidae), *Chrysocharis*, *Closterocerus* (Eulophidae), and *Halticoptera* (Pteromalidae). Possibly the high parasitization of the miners in the spring accounted for the smaller numbers found during the summer.

The leaves of scattered plants (several selections) in fields at Waynesboro, Savannah, and Florence were infested with galls, probably caused by an itonidid fly. Galls collected in August, and isolated for rearing, all yielded parasites, the following species being represented: *Platy-*

gaster solidaginis Ashn. (Scelionidae), *Derostenus*, n. sp., and *Tetrastichus argyrus* Burks ms. (Eulophidae).

Several members of the family Phalaenidae fed upon the leaves of goldenrod and occasionally destroyed the terminal buds, but none of the species occurred in sufficient numbers to cause noticeable damage in the fields. The variegated cutworm, *Peridroma margaritosa* (Haw.), attacked some caged goldenrod plants at Asheville, N. C., and caused severe defoliation in a few days' time. A species of *Cucullia* was collected during May at Waynesboro and Savannah, and *Prodenia ornithogalli* Guen. was taken in May at Florence and Waynesboro, and in August at Clemson, Tifton, and Houma.

Other leaf feeders noticed but which caused little or no damage included another leaf roller (probably a species of *Archips*), grasshopper nymphs, one unidentified geometrid, and an unknown pyraustid species.

INSECTS INJURIOUS TO THE STEM.—Stem borers of the moth family Olethreutidae, apparently two species of *Epiblema*, attacked nearly all the selections grown in different localities in the Southeastern States. An adult that issued from a pupa collected on August 16 at Savannah proved to be *Epiblema tripartitana* (Zell.) and, according to C. Heinrich, this is a new food-plant record for this species. On August 16 at Waynesboro an adult *Epiblema scudderiana* (Clem) was captured in flight. Most of the attempts to rear these stem borers failed as a result of high parasitization.

Small stem-borer larvae were occasionally found feeding in the terminal buds but more often in the stems, 2 to 4 inches below the tips, ingress apparently having been made through small entrance holes which were discernible upon close examination. Sometimes the tunneling and feeding of the larva within the stem resulted in girdling, and the top of the plant either wilted or broke over and died. When the latter occurred, abundant branch development took place on the stem below the break. Some plants, developed well in spite of the larval tunneling in the stems. Such plants were detected in the summer by an elongate-oval swelling or gall formation along the stem. Pupation occurred within the stem, and the adult finally emerged through a hole made in the gall. During August larvae were found infesting some of the larger goldenrod branches, as well as the main stem.

Infestation counts, based on 50 to 100 or more plants for each selection, were made in August at several localities. At Florence only 1 to 4 per cent of the plants, representing 5 selections, were infested. In one Savannah field 16 per cent of the 3S-79 plants and 38 per cent of the 6S-30 plants were infested, whereas in another field 46 per cent of the latter selection had been attacked. Counts made in 5 Waynesboro fields showed that the infestation percentages by selections were approximately as follows: 3S-91 (2 per cent), 3S-40 (3 to 4 per cent), 3S-4A (7 per cent), 3S-79 (6 to 16 per cent), and 6S-30 (42 per cent). Considering only the larger plantings, selections 6S-30 and 3S-79 were most susceptible to stem-borer attack.

Field observations suggested that damage by larvae of the species mentioned, as well as by other stem borers, was of little consequence since many plants survived the attack, and because abundant shoot proliferation followed when the terminals were killed. It is conceivable that the volume of leaves produced on the numerous new branches formed might even exceed that of unattacked plants by harvest time, particularly if the insect attack occurred in the spring. A comparison of the rubber yields obtained from the leaves of topped and untopped goldenrod plots should furnish useful information for indirectly evaluating the influence of severe borer attack on rubber production.

Moth emergence occurred in August in several localities, as evidenced by a few empty pupal skins in emergence holes which had been made by the larvae in the spindle-shaped galls. Most of the infested plants contained either larvae or pupae. Sixteen pupae collected for rearing from Savannah and Cairo all produced hymenopterous parasites, the following species being represented: *Proscus walshiae australis* Cush. (Ichneumonidae), *Spilocalcis flavopicta* (Cress.) (Chalcididae), and *Eupelmus momphae* Gahan (Eupelmidae). Such a high rate of parasitization undoubtedly caused an important reduction in the stem-borer population.

A pterophorid stem borer, *Oidaematophorus* sp., was prevalent in one Waynesboro field in May and in the Houma plant-

ing early in August. Larval attack may be detected by the presence of frass and borings on the leaves and stem, by a small hole in the stem, or by wilting. The larva of this moth may bore into the upper part of the stem and girdle it by localized feeding or else make an extensive tunnel in the pith of the stem. Infested plants were subject to breakage. The damage by a single larva often caused the terminal bud to die, whereupon the plant later developed many shoots in its place and growth was resumed.

Light infestations of a cerambycid beetle, probably *Mecas* sp., were observed in May at Savannah and Waynesboro. The goldenrod stem was apparently girdled by means of two rings of punctures made by the adult prior to oviposition, and as a consequence the plant usually wilted. A single, elongate-oval egg was deposited in the stem, between the two girdles. Tops of infested plants often broke over and died. Later, however, new branches arose below the stem injury.

Scattered plants in a localized area in one field at Waynesboro were infested with larvae of a tephritid fly, probably *Procecidochares atra* (Loew). The larvae occurred in tunnels in the enlarged stems of plants, which showed a marked reduction in height growth and had rosetted terminals.

INSECTS AFFECTING THE ROOTS.—A larva of an olethreutid moth, possibly *Eucosma dorsisignatana* (Clem.), was taken by W. L. Smith in May 1943 at Savannah. This species tunnels and feeds within the underground stolons of cultivated goldenrod.

INSECTS COLLECTED ON GOLDENROD.—Several species were collected on goldenrod that did not appear to be injurious to the 1943 plantings but which may be potential pests. Among these were three species of aphids found feeding on the leaves, stems, and terminals of scattered plants in some fields. In May, *Macrosiphum rudbeckiae* (Fitch) was taken at Florence, Waynesboro, and Savannah, and *M. ambrosiae* (Thos.) at Savannah. The former species was partially controlled in some fields by the labybird beetle *Hippodamia convergens* Guér. Another aphid, *M. erigeronensis* (Thos.), was collected in August at Andalusia and Houma.

Nymphs of a cercopid, *Lepyronia quadrangularis* (Say), were collected from spittle masses on selections 6S-30 and 3S-79 in several localities. Although a heavy infestation of this spittle bug occurred in August on a plot of 6S-30 at Florence, no visible damage was detected.

A common leafhopper found on cultivated goldenrod was *Oncometopia lateralis* (F.). Adults (including mating pairs), nymphs, and cast skins were found on different selections.

Small numbers of other species taken on goldenrod were as follows: adults and nymphs of *Chelysoma guttatum* (H. S.) in August at Savannah, nymphs of *Oecanthus nigricornis quadripunctatus* Beut. adults of *Cebrio bicolor* F. in May at Waynesboro, and an *Ormenis* nymph in August at Waynesboro.

SUMMARY.—A survey in 1943 of the cultivated goldenrod plantings in five southern States revealed attacks by many insects with diverse habits. Some of the common forms encountered were thrips, stem borers, aphids, leaf rollers, leaf-feeding caterpillars, leaf miners, and leafhoppers. The identity, life history, and economic importance of most species are incompletely known.

Thrips feeding on the terminal growth caused it to become stunted. The damage caused by stem borers was apparently of minor importance since many plants survived the attack, and because abundant shoot proliferation took place after the terminals were killed. Selection 6S-30 was most susceptible to attack by the above-mentioned species. Some of the stem borers were partially held in check by hymenopterous parasites.—10-5-44.

DR. FRISON ILL

Dr. T. H. Frison, Vice-President of the Association and formerly Editor of the JOURNAL, is confined to a hospital bed with an undiagnosed illness. On behalf of Dr. Frison's many friends in Entomology the JOURNAL extends sympathy and hopes for an early recovery.

The Coverage Factor in the Application of Dusts

NEELY TURNER, *Connecticut Agricultural Experiment Station, New Haven*

A study of the problem of meeting wartime shortages of insecticides indicated that if a farmer were to obtain only half of his normal supplies he could produce more food by covering all his normal acreage with half his normal dosage than by covering half his acreage with normal dosage (Turner & Horsfall 1942). There are two ways of reducing dosage (1) by reducing concentration of toxicant in the mixture applied and (2) by reducing in one of several ways the amount of mixture applied per acre. Little information was available as to the relative effects of these two methods. Horsfall & Heuberger (1942) published data on spraying tomatoes by varying both concentration of copper oxide and gallons applied per acre. One test showed that the control of defoliation diseases dropped more rapidly when the rate per acre was reduced, the other resulted in just the reverse. Their data also indicated that reductions in concentration could be offset by applying larger gallonages of much weaker concentrations. More recently Tattersfield & Potter (1943) have shown that increasing the concentration of pyrethrins in oil was more effective in killing *Tribolium* than an equivalent increase in the deposit of a given concentration. Obviously, then, reducing the concentration would decrease control more rapidly than application of a smaller deposit by reducing the amount of spray applied per unit area.

These workers shed some light on the subject of spraying, but even so there was no agreement. Some information on dusting was available. Smith (1938) killed snowy tree crickets with 3.75 mg./sq. in. of barium fluosilicate in a 30 per cent dust, while 6.6 mg./sq. in. were required when the undiluted material was applied. Michelbacher *et al.* (1940) found that a heavy application of 40 per cent cryolite-talc dust was more effective than half as many pounds per acre of 80 per cent cryolite in controlling tomato fruitworms.

Wilcox (1943) applied 70 per cent, 50 per cent and 35 per cent cryolite-talc dusts for tomato fruitworm control at equal amounts of cryolite per acre. There was a slight difference, not statistically significant, in favor of the most dilute dust. He concluded that undiluted dust was more economical on a cost basis.

Gray & Schuh (1940) found that 40 pounds of 0.75 per cent rotenone dust was more effective in controlling pea aphids than 120 pounds of 0.25 per cent rotenone dust. Dudley & Bronson (1944) applied 20, 40 and 60 pounds of rotenone dust in their series of tests with the concentrations adjusted so that .075, 0.15 and 0.30 pounds rotenone per acre were used. The conclusion reached was that at the 0.30 pound rate it made little difference whether a high or low concentration dust was used at a low or high rate; when 0.15 pound or less was applied, the high concentration at a low rate was preferable.

These tests show no clear distinction between concentration and amount applied per acre. In fact all three possibilities were noted: (1) no difference, (2) in favor of concentrated dusts and (3) in favor of dilute dusts. It is not simply a question of technique, or materials or insects, because Dudley & Bronson (1944) noted two of the three using the same material on the same pest.

It is common knowledge that insects are killed by toxicants deposited either on the insects (contact insecticides) or on the plant and actually consumed by the insects (stomach poisons). As far as the insect is concerned, there is no difference between a fatal dose of derris, for example, applied as 1 per cent rotenone dust or as 0.125 per cent rotenone dust. An insect survives treatment because a fatal dose of toxicant did not reach it for one of two reasons, either no insecticide at all reached it, or the dose which did get there was too small to be fatal. In the first case the survival would be caused by a lack of coverage; in the second from lack of insecticide in the mixture used. In other words two probabilities are involved in the application of insecticides: (1) the probability of reaching the insect with any insecticide at all, or coverage, and (2) the probability of killing the insect with the dose that reaches it, or dosage. These must be distinguished in order to solve the problem. Fortunately the dosage response technique can be used for the purpose. Dimond *et al.* (1941) have shown that the slope of

Table 1.—Effect of concentration of rotenone in derris-pyrophyllite dust on mortality of *Myzus persicae* Sulz. in the laboratory.

Conc.	Number		% Dead
	Dead	Alive	
0.0625	33	52	38.8
	85	57	59.9
	49	88	35.8
0.125	67	62	51.9
	82	68	54.7
	79	121	39.5
0.25	77	45	63.1
	79	77	50.6
	50	37	57.5
0.5	52	37	58.4
	97	38	71.8
	103	49	67.8
0.6	99	29	77.3
	72	97	42.6
	155	98	61.2
0.7	96	119	83.5
	41	35	53.9
	54	22	71.1
0.8	197	96	67.2
	145	51	73.9
	74	35	67.9
0.9	97	41	70.8
	86	27	76.1
	58	36	61.7
1.0	97	55	63.8
	117	58	66.9
	80	56	58.8
1.4	214	42	83.6
	68	33	67.3
	78	34	69.6
2.0	110	51	68.3
	86	52	62.3
	153	52	74.6
3.0	71	52	57.7
	127	77	62.3
	91	65	58.3

a dosage response curve may be changed by changing coverage. If a series of concentrations of materials are used in a series of methods of application, the methods providing better coverage should result in a steeper dosage response curve. The position of the curve would be determined by the relative size of the dose reaching the insect.

Obviously the principal factor affecting the probability of killing the insect when it was hit would be the concentration of toxicant in the material. The factors affecting the probability of hitting the insect are more complex and less well known. Amount applied per unit area, electrostatic charge, number of nozzles,

FIG. 1.—Dosage-response curve for concentration of derris-pyrophyllite dust. *Myzus persicae* Sulz. in laboratory tests.

type of nozzles, arrangement of nozzles, volume of air, speed of air movement and ground speed of the machine are all possibilities.

EFFECT OF CONCENTRATION.—Mortality is supposed to increase as the concentration of toxicant increases. Plotted arithmetically, data from such experiments form a sigmoid curve, which can be converted to a straight line by plotting dosage as logarithms and mortality as probability (O'Kane *et al.* 1930; Bliss 1935). If concentration of toxicant in diluent has any abnormal effect on mortality, it should appear as an abnormality in the dosage response curve, regardless of the method of plotting. Wilson & Janes (1942a) published data showing that toxicity to pea aphids did not increase as the concentration of rotenone in the dust was increased. In fact 0.75 per cent rotenone killed a smaller percentage of aphids than any less concentrated dust. Turner (1943) reported that 1 per cent rotenone dust was less toxic to *Aphis rumicis* than 0.5 per cent rotenone.

More recently Wilson *et al.* (1944) have published a series of results using different diluents. In half of the tests increasing concentration did not always increase mortality. Wilson *et al.* (1941), Wilson & Janes (1942a) (1942b), and Wilson *et al.* (1944) have discussed the effect of electrostatic charge on control. They found that some diluents produced a high electrostatic charge when blown from a high-velocity duster. This charge was reduced when rotenone-bearing root was added and when equal parts of root and diluent were mixed the charge sometimes dropped to zero. Addition of more root increased

the charge again but also changed it from positive to negative.

Assuming that electrostatic charge does affect control, then a series of concentrations of derris dust with a pyrophyllite diluent might be expected to perform differently than the normal. This is in fact what does occur. The dosage-response curve published for toxicity of derris-pyrophyllite dust to *Aphis rumicis* L. was not plotted as a straight line (Turner 1943). In an effort to establish the character of this curve derris was applied in rotenone concentrations of from 0.0625 to 3 per cent, with pyrophyllite as the diluent. The results of one of three series of such tests have been tabulated in table 1, and a curve for the average control plotted in figure 1. This curve is presented as a *possibility* and not as a proved solution. It has been drawn by connecting the mid-points of the three replicates. There are apparently no statistics available to prove or disprove its shape and position. Certainly in every replicate there appeared low and high points. These did not always synchronize with dosage, as a careful inspection of table 1 will show. Whether or not this particular curve is

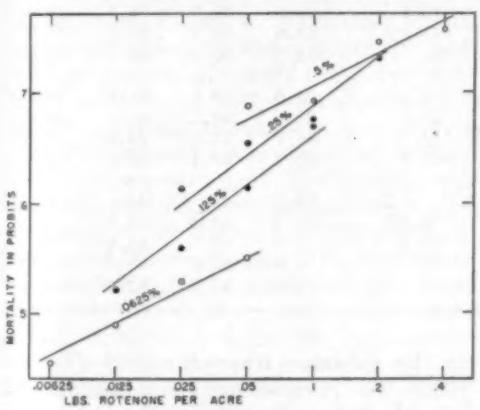


FIG. 2.—Dosage-response curves for four concentrations of derris-pyrophyllite dust applied to beans for control of the Mexican bean beetle at 10, 20, 40 and 80 pounds per acre.

acceptable, the fact remains that the relation between concentration and mortality is abnormal.

Furthermore, any curve fitted to these data would resemble a curve for a periodic phenomenon much more closely than a typical dosage-response curve. It is proposed that this is a periodic curve, and that the two factors acting sometimes together and sometimes in opposition are concenration and electrostatic charge. The normal effect of increasing concentration is increased mortality. The normal

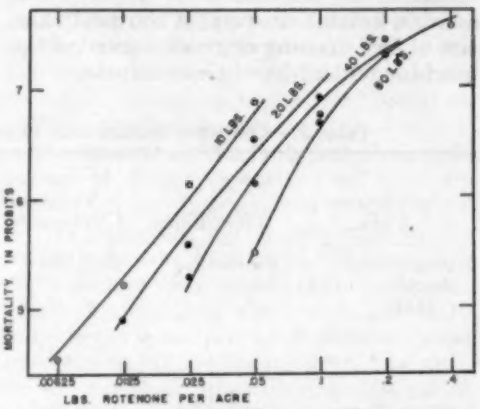


FIG. 3.—Dosage-response curves for four rates of application of derris-pyrophyllite dust applied to beans for control of the bean beetle at concentrations of .0625, 125, 125 and 0.5 per cent.

effect of reduced proportions of pyrophyllite is a lower electrostatic charge (Wilson & Janes, 1942a). When lowered charge was more important than increased concentration, mortality was reduced, and *vice versa*.

It is proposed further that the difficulty in establishing the "low" and "high" points on the curve is caused by variations in the intensity of electrostatic charge between replicates.

Wilson & Janes (1942a) have given the reasons for the effect of electrostatic charge. They state: "When a high charge is produced, the dust particles stand out on the legs and antennae like iron filings on a magnet." Some diluents resulted in even distribution on the stems and both sides of the leaves, others dispersed unevenly and settled more on the upper surface of the leaves, with little or none on the lower surfaces or stems (Wilson *et al.*, 1941). In other words, electrostatic charge had an important effect on coverage of the foliage.

To summarize, the effect of increasing concentration of toxicant is normally an increase in mortality. When increasing concentrations mean large decreases in amount of diluent and consequently large changes in intensity of electrostatic charge, coverage is also affected.

EFFECT OF AMOUNT APPLIED.—This has been discussed above; briefly stated, the results of several tests showed no general agreement.

OTHER FACTORS.—Nothing has been found in the literature on the effect of nozzles, volume or speed of the airstream, size of feed opening or ground speed of the machine on the deposition of dusts.

control cabbage worms and larvae of the Mexican bean beetle. All were applied with a rotary hand duster, with the amounts per acre varied by adjusting the feed slot or by varying the ground speed. In the case of the Mexican bean beetle, results were obtained by counting the larvae present on 10 plants from each of the three or four replicated plots. Damage

Table 2.—Control of insects with varied amounts of different dust combinations.

INSECT AND YEAR	DUST USED	VARIATION CONTROLLED BY	CONCENTRATION (PER CENT)	POUNDS PER ACRE AND CONTROL			
Mexican Bean Beetle 1942	Derris-Clay	Feed-slot		12	24	48	
			0.125	—	53.4	—	
			0.25	51.1	70	84.5	
			0.5	81.7	88.1	95.4	
			1.0	96.3	97.2	99.4	
			2.0	—	98.1	—	
Cabbage Worms (Marketable Heads)	Derris-Clay	Feed Slot	0.25	16.3	26.9	27.8	
			0.5	42.5	55.8	57.5	
			1.0	46.3	63.2	68.4	
Bean Beetle Larvae 1943	Derris-Pyrophyllite	Time of Dusting	—	10#	20#	40#	80#
			0.0625	32.3	46.4	59.3	69.0
			0.125	58.1	71.1	86.7	95.5
			0.25	85.6	93.3	95.4	98.7
			0.5	96.6	97.1	99.1	99.4
Bean Beetle Larvae 1943	Cryolite-Pyrophyllite	Time of Dusting	6.25	25.6	16.9	16.9	64.3
			12.5	26.9	37.0	74.7	74.3
			25	63.6	86.1	92.0	97.9
			50	94.1	90.3	95.1	95.8
Cabbage Worms (Per cent *not* damaged)	Cryolite-Pyrophyllite	Time of Dusting	6.25	25.0	13.6	38.6	48.1
			12.5	22.8	40.7	51.0	65.7
			25	41.2	55.0	59.6	68.5
			50	57.4	65.4	69.6	77.9
Bean Beetle Larvae 1944	Cryolite-Pyrophyllite	Feed Opening		12	24	48	
			6.25	38.1	43.4	49.3	
			12.5	55.0	57.5	64.6	
			25	52.2	85.0	88.5	
			50	79.6	85.8	93.0	

EXPERIMENTAL. — Laboratory tests made during 1942 using a series of concentrations of derris dust applied to aphids in a series of different-sized deposits failed to produce clear-cut results. The effect of the electrostatic charge, discussed above, was probably responsible for the variations. Moreover, all aphids were exposed directly to the dust and under such conditions the probability of hitting them would be high in all cases. Therefore most of the tests were made in the field where differences might be greater.

Derris-clay, derris-pyrophyllite and cryolite-pyrophyllite dusts were used to

to the cabbage was estimated (Turner 1943). The results have been summarized in table 2. Examination of the individual figures shows 33 cases in which the larger amount of lower concentration dust was less effective than the smaller amount of higher concentration dusts. In only 10 cases was the reverse true. Moreover in plotting dosage response curves in which the dosage is the amount of toxicant used per acre, the low application rate of high concentration dust is always the most effective.

For an exposition of the principles involved, the data from table 4 have been

plotted on the logarithmic-probability grid (Figs. 2 & 3). All curves have been fitted mathematically.[1] In figure 2 the four concentrations are plotted with log of amount of derris used as the abscissa. They represent, for instance, 0.5 per cent rotenone dust applied at 4, 8, 16 and 32 seconds dusting time per 20 foot row, and resulted in approximately 10, 20, 40 and 80 pounds of dust applied per acre. The curves are rectilinear but are not all parallel. According to the hypothesis, the changes in slope should represent only a change in coverage. In other words 0.125 per cent and 0.25 per cent rotenone dusts possessed some quality which resulted in more efficient action. This could be electrostatic charge, which might be expected to have such an effect. However, within the limits of this experiment the 0.5 per cent dust was more effective than the 0.25 per cent in terms of amount of rotenone applied.

The curves for dusting times (pounds per acre) are shown in figure 3. Here the abscissa is the amount used, and the points represent changes in concentration. There is little evidence that increasing the dusting time was more efficient. Moreover, as dusting time increased the curves depart from linearity. When the plants were dusted for 32 seconds per 20 foot row (80 pounds per acre) the curve flattened rapidly as the concentration increased. The reason seems to be that less dust than expected was deposited in relation to the amount used. The dosage used has been plotted, but the mortality was the result of the dosage actually reaching the insects. There appears to be no method for measuring the dosage deposited on the insects so that the curvature can be corrected. Apparently a straight line results only when the deposit is arithmetically related to the amount used.

From the standpoint of the farmer, the amount used is the important figure. We can, therefore, forget the curvature long enough to conclude that in terms of efficiency, 10 pounds of 0.5 per cent rotenone dust (.05 pound rotenone) was as effective as 20 pounds of 0.41 per cent (0.08 pound rotenone), 40 pounds of 0.25 per cent (0.10 pound rotenone) or 80 pounds of 0.165 per cent (0.132 pound rotenone).

All of the experiments agree in that there was no indication of an improvement in coverage resulting from application of larger amounts of material by the methods used.

The data of Dudley & Bronson (1944) plotted in the same manner, show that 40 and 60 pounds per acre produced a slightly steeper slope than 20 pounds. Moreover the curves crossed giving further support to their conclusions which were based on amount applied per acre.

DISCUSSION.—The fact that the application of larger quantities of dust by larger feed opening or slower ground speed did not provide better coverage by no means exhausts the subject. There are still other factors to be tested. Apparently the smallest amount of dust used, about 10 pounds per acre, provided about as good coverage as 80 pounds per acre. The data do show without question that the use of small amounts of high concentration dust is more efficient than larger quantities of low concentration dusts. It is impossible to determine how far this can be carried until equipment suitable for applying very small quantities of dust per acre can be developed.

It is evident, however, that a tremendous saving in materials can be made by reducing the amount per acre and using a more concentrated dust. In the experiment examined in detail the saving in rotenone was half when the amount was reduced from 40 to 10 pounds and the concentration raised from 0.125 per cent to 0.5 per cent. In the 1942 experiment on beans (Table 2) 0.12 pounds of rotenone per acre in derris-clay dust containing 1 per cent rotenone provided better control than 0.24 pounds rotenone applied as 0.5 per cent dust at 48 pounds per acre.

SUMMARY AND CONCLUSION.—Two probabilities are involved in the application of dusts in the field: (1) the probability of reaching the insects with any insecticide at all (coverage) and (2) the probability of killing the insect with the dose that hits it (dosage). These can be distinguished by properly-designed dosage-response experiments.

Concentration of toxicant in the dust affects the probability of killing the insect.

Of the factors which might affect coverage, concentration of toxicant and amount applied per acre were studied.

Concentration affected coverage because variations in amount of diluent af-

[1] Statistical analysis and fitting of curves was done by C. I. Bliss.

fected the electrostatic charge developed in the process of applying the dust.

Amount per acre within the limits used, (10 to 80 pounds) had little or no effect on coverage.

In terms of efficiency, small amounts of higher concentration dusts were preferable to high amounts of low-concentration dusts.

In reducing amount used per acre, less control is lost if fewer pounds of dust are applied, rather than the same number of pounds of a lower concentration.—12-15-44.

LITERATURE CITED

Bliss, C. I. 1935. The calculation of the dosage mortality curve. Ann. Appl. Biol. **22**: 135–67.

Dimond, A. E., J. G. Horsfall, J. W. Heuberger and E. M. Stoddard. 1941. Role of the dosage-response curve in the evaluation of fungicides. Conn. Agr. Expt. Sta. Bul. **451.**

Dudley, J. E. Jr., and T. E. Bronson. 1944. Dust mixtures and rate of application in pea aphid control. JOUR. ECON. ENT. **37**: 643–6.

Gray, K. W., and J. Schuh. 1940. Pea aphid control experiments in Oregon. JOUR. ECON. ENT. **33**: 72–7.

Horsfall, J. G., and J. W. Heuberger. 1942. Causes, effects and control of defoliation on tomatoes. Conn. Agr. Exp. Sta. Bul. **456.**

Michelbacher, A. E., G. F. MacLeod and W. M. Hoskins. 1940. Investigations of caterpillars attacking tomatoes in northern California. Calif. Agr. Expt. Sta. Bull. **644.**

O'Kane, W. C., W. A. Westgate, L. C. Glover and P. R. Lowry. 1930. Surface tension, surface activity, and wetting ability as factors in the performance of contact insecticides. New Hampshire Agr. Expt. Sta. Tech. Bul. **39.**

Smith, L. M. 1938. Relation of concentration of active ingredient to insecticidal efficiency of dusts. JOUR. ECON. ENT. **31**: 598–602.

Tattersfield, F., and C. Potter. 1943. Biological methods of determining values of pyrethrum preparations (particularly extracts in heavy oil). Ann. Appl. Biol. **30**: 259–79.

Turner, N. 1943. The effect of diluents on the toxicity of pure ground derris root in dusts. JOUR. ECON. ENT. **36**: 266–272.

Turner, N., and J. G. Horsfall. 1942. Meeting the spray material shortage. Conn. Agr. Expt. Sta. Bul. **455.**

Wilcox, J. 1943. Rate of application and strength of cryolite dust mixtures in tomato fruitworm control. JOUR. ECON. ENT. **36**: 700–5.

Wilson, H. F., C. E. Dieter and H. L. Burdick. 1941. Insecticidal dusts. Soap and Sanitary Chemicals **17**(4): 99–101.

Wilson, H. F., and R. L. Janes. 1942a. Lower concentrations of rotenone. Soap and Sanitary Chemicals **18**(3): 93–5.

Wilson, H. F., and R. L. Janes, 1942b. Carriers of rotenone dusts. Soap and Sanitary Chemicals. **18**(4): 103–5.

Wilson, H. F., R. L. Janes and E. J. Campau. 1944. Electrostatic charge effects produced by insecticidal dusts. JOUR. ECON. ENT. **37**: 651–5.

FIRE LOSS AT PURDUE

The Department of Entomology of Purdue University Agricultural Experiment Station received a severe set-back in its fruit insect investigations when fire, as a result of lightning, destroyed all the buildings and equipment at its Entomological Experimental Orchard near Mitchell, Indiana, June 16th. No one was at the orchard at the time of the fire, which destroyed the packing shed, implement shed, office, insectary, and water tank, and including all equipment, such as tractor, sprayer, well pump, plow, and other farm equipment; also all insecticides, tools, laboratory equipment, office equipment and files. The loss is estimated at $8,000.00, which was covered by $3,000.00 insurance. Coming at this season of the year the loss to the research work in progress is doubly felt.

VEGETABLE WEEVIL IN OKLAHOMA

Beetle specimens collected at Guthrie, Oklahoma, May 14, 1945 have been identified by Mr. L. L. Buchanan through the courtesy of Dr. C. F. W. Muesebeck, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, as *Listroderes obliquus* Klug, the vegetable weevil. Later collections were made near injured tomatoes in Stillwater, Oklahoma. This is the first report of this insect from Oklahoma.

The only plants injured in the gardens examined were tomatoes.

It is assumed that the insect is widespread in Oklahoma, since Guthrie and Stillwater are located in the north-central part of the state, and prior infestations have been reported only from states to the south and east.

Transmission of American Foulbrood by Heated Spores of *Bacillus larvae* and Their Growth in Culture

C. E. Burnside, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

In 1940 the writer (Burnside 1940) reported on some cultural tests with heated spores of *Bacillus larvae*, the cause of American foulbrood of bees, and on a few preliminary tests in which colonies were inoculated with boiled spores. It was found that spores sometimes grew in culture after they had been heated for much longer periods than was previously thought sufficient to kill all of them. On the other hand, spores that had been boiled for relatively short periods and remained capable of growing in culture did not produce American foulbrood when inoculated into colonies of bees. These results were thought to indicate that the virulence (ability to infect honeybee larvae) of heated spores may be destroyed by heating much sooner than is their viability (ability to grow in culture).

The work described in this paper is a continuation of that reported in 1940. The experiments were begun at Beltsville, Md., in the spring of 1937 and continued there until the summer of 1942. Their purpose was to determine in what manner heating affects the virulence of *Bacillus larvae* spores and how such effect compares with the effect upon their viability. Tests were made with spores boiled in water or in honey diluted with water, with spores heated in beeswax and artificially incorporated in brood foundation made of the wax, and with brood foundation made of wax rendered from American foulbrood combs.

Most of the spores were taken from diseased combs used in foulbrood-resistance studies at the Intermountain States Bee Culture Field Laboratory at Laramie, Wyo., although foulbrood combs obtained from other parts of the country were also used. The honey was produced at Beltsville, largely from tuliptree nectar. The beeswax, a good grade of purified cappings, was purchased on the open market. Colonies of bees that covered from 8 to 20 combs in the experimental apiary were used for inoculation tests.

Tests With Boiled Spores.—Spores of *Bacillus larvae* were heated by boiling them in a covered vessel over an open flame. This method of heating was used because boiling for different periods, especially for 30 minutes, often has been used by beekeepers as a means of salvaging honey and equipment from colonies affected with American foulbrood.

Spores for boiling in water were obtained by placing foulbrood scales in boiling water containing glass beads. After boiling (at 99.3° C.) the suspension was cooled quickly by adding water chilled to about 2° C. and by setting the vessel in ice water. Scales that did not dissove during boiling were macerated by shaking them with the glass beads in the water in which they were boiled.

Spores intended for boiling in diluted honey were separated by shaking American foulbrood scales in water with glass beads. Diluted honey, ranging in quantity from 2.5 to 10 liters in different tests, was warmed to 70° C., and enough spores were stirred in to give a suspension containing approximately 500 million spores per milliliter. The suspension was boiled for a predetermined period. Boiling began at 102.8° C., but the temperature rose slightly as boiling continued. The suspension was allowed to cool at room temperature.

Spores for cultural tests were recovered from the boiled suspensions by centrifuging. The viability of the spores was tested by culture methods described by the writer in 1940. The results are shown in table 1.

Sixty-two colonies of bees were inoculated by feeding each of them 500 billion boiled spores in a liter of 50 per cent honey solution or sugar syrup. Six colonies received spores boiled 5 minutes, 8 colonies spores boiled 10 minutes, 16 colonies spores boiled 15 minutes, 12 colonies spores boiled 30 minutes, and 4 colonies spores boiled each of the following periods: 1, 2, 3, 4, and 5 hours.

Colonies were inspected for American foulbrood at weekly intervals as long as weather conditions permitted during the year that they were inoculated. Thereafter they were inspected about once a

[1] In cooperation with the University of Wyoming.

Table 1.—Vegetative growth of *Bacillus larvae* spores boiled for various periods in water and diluted honey.

Boiling Medium	Boiling Period	Cultures Prepared	Cultures Growing	Minimum Incubation Period
Liters	*Minutes*	*Number*	*Per Cent*	*Days*
Water:				
0.5	30	88	0	30+
	60	38	63	6
	120	78	64	17
	180	58	31	4
	240	63	14	20
	300	30	0	30+
Diluted honey:				
2.5	30	29	72	5
	60	31	82	6
	120	49	18	6
	180	32	63	15
	240	41	15	7
	300	40	10	10
5.0	15	230	13	4
	30	166	26	8
10.0	5	70	19	4
	10	80	15	22
	15	120	3	4
Not boiled (check)	0	90	100	1

month during the bees' active season. All the inoculated colonies remained free from active American foulbrood during the entire time that they were under observation.

SPORES HEATED IN BEESWAX.—Scales of American foulbrood that had been dried over calcium chloride were ground in melted beeswax in a mortar. This procedure resulted in fine separation of the scale material, but separation of individual spores was not so complete as can be obtained by shaking scales in water with glass beads. After being ground the spores were stirred into a larger quantity of beeswax held at approximately 90° C. This wax suspension of spores was sprayed onto 40 sheets of commercial brood foundation. The hot wax fused with the wax of the foundation and formed a rough layer over the surface. One hundred and ten sheets of brood foundation were made from the wax suspension of spores on a hand (*Reitsche*) foundation press.

In another series of tests wax was rendered from American foulbrood combs that contained scales in about 5 per cent of the cells, and then purified by straining through cheesecloth and solidifying over water. Large numbers of spores either settled out of the wax into the water or collected in the lower impure layer of the wax cake, which was cut away and discarded. Relatively few spores could be found in the purer layers of the wax. Forty sheets of brood foundation were made of this wax on a hand foundation press.

Nineteen colonies were inoculated by giving each of them 10 sheets of the especially prepared foundation containing spores of *Bacillus larvae*. Either the sheets of foundation were placed alternately between combs of brood or all the combs of a colony were placed above a queen excluder while the queen and about half the bees were put on the foundation below. The foundation was drawn promptly by the bees, and the queen began laying in the new combs within 1 to 3 days.

The colonies were inspected for American foulbrood once a week for a month and thereafter at monthly intervals during the active season. Results of the colony inoculations are shown in table 2.

Table 2.—Occurrence of disease in colonies of bees given 10 sheets of brood foundation containing spores of *Bacillus larvae* heated in the wax at 90° C.

Treatment of Wax Containing Spores	Minimum Period of Heating[1]	Spores Per Sheet of Foundation	Results of Inoculations
	Minutes	*Billion*	
	Colonies inoculated in August 1937		
Sprayed onto foundation	5	25	No disease
		37.5	No disease
		37.5	Diseased August 1938
		100	Diseased May 1938
	Colonies inoculated in June 1940		
Made into foundation	30	40	Diseased September 1941
	95	40	Diseased September 1941
	160	40	No disease
	225	40	No disease
	290	40	No disease
	355	40	No disease
	30	120	Diseased August 1940
	95	120	Diseased September 1940
	160	120	Diseased September 1940
	225	120	Diseased September 1940
	290	120	Diseased June 1941

[1] The maximum period of heating was 20 min. longer than the minimum for wax sprayed onto foundation and 65 min. longer for wax made into foundation. The foundation for each group was made one sheet at a time. The difference between the minimum and maximum periods of heating represents the time that elapsed between completion of the first and the last sheet of each group of 10 sheets. As soon as a sheet of foundation was made the wax immediately cooled.

In July 1941 four other colonies were given foundation made of wax rendered from American foulbrood combs. All these colonies remained free from American foulbrood.

DISCUSSION.—In evaluating these re-

sults the sterilizing effect of subboiling temperatures as well as the period of boiling must be considered. In 1940 the writer showed that when the temperature reaches 66° C. sterilization of spores has already begun. Without doubt there would be a considerable sterilizing effect, particularly upon the least heat-resistant spores, if the suspensions were only heated to boiling and then allowed to cool.

It was also shown previously that spores retain their viability longer when heated in beeswax than when heated at the same temperature in water, steam, or hot air. One reason for this may be that the wax retards change in the moisture content of the spores. It seems probable that their virulence is similarly protected, and this may help to explain why spores heated in beeswax produced American foulbrood while spores heated shorter periods in water or diluted honey did not.

It should be emphasized that the inoculations with spores incorporated in brood foundation were artificial, and that the wax contained many times as many spores as ever occur in foundation under natural conditions. The results should not be taken to indicate that disease is likely to be transmitted through commercial foundation made of wax rendered from diseased combs. In fact, colonies given foundation made entirely of such wax remained healthy. In the crude rendering of wax from diseased combs in hot water, most of the spores settled out of the wax. Thorough purification and additional heating of wax in the manufacture of commercial foundation would seem to eliminate all danger of disease being spread by the foundation.

A characteristic of cultures inoculated with heated spores of *Bacillus larvae* was a decrease in the percentage of spores that germinated as heating was prolonged, accompanied by an increase in the length of the incubation period, but different individual cultures varied considerably in both these characteristics. Relatively short periods of heating seemed to destroy most of the spores, but a few showed extreme resistance to heat. The germination of the few spores that remained alive after prolonged heating was delayed for several days to several weeks. These observations suggest that spores capable of germinating soonest are among the first to be destroyed by heating.

Woodrow (1941) reported that brood is most susceptible to American foulbrood during the first day of larval life, and that larvae more than 2 days and 5 hours old do not become infected. It would seem, therefore, that heated spores which require more than 2 days and 5 hours longer than normal to germinate cannot cause American foulbrood, because larvae will have passed their susceptible age before the spores can grow. Furthermore, if heating has been long enough so that surviving spores have a materially prolonged incubation period, relatively few spores remain alive.

In the past a distinction was not made between viability of *Bacillus larvae* in culture and virulence for brood of bees. If spores grew in culture they were considered infectious. The present results show that when spores are heated—and the same is probably true of subjection to other lethal agents—surviving spores that are capable of growing in culture only after prolonged incubation are unlikely to cause American foulbrood.

Several theories have been presented to explain the variation in germination time of spores and the long incubation period required for start of vegetative growth in micro-organisms that survive exposure to lethal agents. Among these are injury to the organisms, reduction of vital enzymes which must be restored before growth can occur, lack of specific favorable conditions in the culture medium, exacting metabolic requirements of the surviving spores, and thick and nearly impervious walls of a few spores which render them more resistant and cause them to germinate slowly.

Work reported by Burke (1923) and others indicates that high heat resistance and delayed germination are associated in the same spores, and that spores which resist long heating would have germinated only after prolonged incubation had they not been heated. The evidence seems to indicate that the latter explanation may also apply to *Bacillus larvae*. It may also follow that spores able to germinate most rapidly are most virulent for brood of bees but are the least resistant to heat, while those most resistant to heat are normally not virulent.

The present results, as well as those of White (1920) and of the writer (1940). indicate that 30 minutes' boiling can be

depended upon to destroy the virulence of *Bacillus larvae* spores under any ordinary conditions. Under highly favorable conditions, or when spores are heated at subboiling temperature before boiling begins and are allowed to cool slowly after boiling has been discontinued, the period of boiling can in some instances be reduced.

SUMMARY.—A study has been made of the effect of heating *Bacillus larvae* spores on their viability and on their ability to transmit American foulbrood to honeybee colonies.

Spores were boiled for different periods up to 5 hours in water and in honey diluted with an equal amount of water. When tested by culturing on nutrient medium, many of the boiled spores grew after prolonged incubation, but American foulbrood was not produced in any of 62 colonies of bees inoculated with these spores.

Spores were also heated for different periods in beeswax, which was then incorporated in brood foundation either by spraying onto commercial foundation or by making wax rendered from American foulbrood combs into foundation. Colonies were inoculated by giving them 10 sheets of the foundation. American foulbrood was produced in 2 out of 4 colonies given spores in the wax sprayed onto foundation and in 7 out of 15 colonies given foundation made of wax from American foulbrood combs.

In the manufacture of commercial wax foundation thorough purification and heating of the wax probably alleviates all danger of disease being transmitted through the foundation.

Spores of *Bacillus larvae* that are normally capable of germinating soonest are probably the most highly virulent but are the first to be destroyed by heating. Spores that normally require prolonged incubation to germinate are highly resistant to heating but probably are not virulent. Spores that require 2½ days or more longer than normal to germinate cannot cause Infection, since larvae pass their susceptible age before the spores can grow.

Boiling for 30 minutes can be depended upon to destroy the virulence of spores of *Bacillus larvae* under any ordinary conditions.—3-12-45.

LITERATURE CITED

Burke, G. S. 1923. Studies on the thermal death time of spores of *Clostridium botulinum*. 3. Dormancy or slow germination of spores under optimum growth conditions. Jour. Infect. Dis. 33(4): 274–84.

Burnside, C. E. 1940. The thermal resistance of *Bacillus larvae*. JOUR. ECON. ENT. 33(2): 399–405.

White, G. F. 1920. American foulbrood. U.S.D.A. Bul. 809.

Woodrow, A. W. 1941. Susceptibility of honeybee larvae to American foulbrood. Gleanings in Bee Culture. 69: 148–51, 190.

INDEX TO "FOOD-PLANT CATALOG OF THE APHIDS"

Certain entomologists who have used Maine Experiment Station Bulletin 393, *Food-Plant Catalog of the Aphids of the World* by Dr. Edith M. Patch, have suggested that an index to genera and species of the food plants would facilitate the use of the bulletin, in which the plant index is restricted to plant families. In response to this friendly suggestion, a supplementary, detailed plant index has been prepared by Miss Alice Averill and published as Maine Bulletin 393-S. Any entomologist who cares to use the new index may obtain a copy free upon request to the Maine Agricultural Experiment Station, Orono.

Dr. Patch's *Food-Plant Catalog of the Aphids of the World*, Maine Bulletin 393, is still available to entomologists or others who need the publication.

P.H.L.

The Effect of DDT on Honeybees

J. E. Eckert, *University of California, Davis*

Introduction.—A prodigious amount of effort has been expended since 1942 in experimenting with dichloro-diphenyl-trichloroethane, or DDT, to determine its toxicity to mammals, insects, and plants. Since this poison is being manufactured in quantity for war purposes, its release for civilian use is supposed to be limited to experimental applications. Whether it will ever be generally adopted as a general insecticide may depend upon the results and recommendations of research agencies.

In preliminary experiments by Annand (1944) and others, DDT has proved toxic to a large number of insects, both as a contact and as a stomach poison. It was first erroneously considered harmless to the honeybee. Holst (1944) however, reported DDT not only served as a stomach poison to bees but also a 1 per cent concentration of it acted as a contact poison. In the work of Filmer and Smith (1944), bees were killed when exposed to 0.00041 gram of DDT per square inch of surface over which they had to crawl for 20 to 30 minutes. Hambleton (1944) informed the beekeeping industry that DDT was highly toxic to bees both internally and externally.

The gathering of nectar, pollen, propolis, and water brings the honeybee into direct contact with any chemical substance applied to the source of these products. Its anatomy and physiology make the bee susceptible to injury by most of the stomach poisons or fumigants used in controlling. insect pests. Normally, the colony is affected most by the stomach poisons, although field bees are often destroyed by contact with nicodust, pyrethrum, derris, and rotenone, substances effective primarily because of their volatility or become ineffective after a short exposure to air. Never before has the bee been threatened by a nonvolatile chemical that apparently injures its nervous system by contact as well as by ingestion.

The present studies were made in an attempt to evaluate the effect DDT might have on the beekeeping industry if its use ever becomes general, with no more restrictions than the inadequate few now governing the manufacture, sale, and use of other insecticides.

Methods and Materials.—Honeybees were exposed to DDT (1) when a solution was sprayed on cages in which the bees were later confined; (2) when various concentrations of dusts were sprinkled on them in cages and in their hives; and (3) when the poison was mixed with queen-cage candy, pollen, and sugar sirup. Since honeybees lack uniformity as experimental subjects, it is difficult to approximate natural results under artificial conditions.

DDT as a Contact and Stomach Poison.—A wooden box with screened top and bottom, measuring $4 \times 2.5 \times 3.5$ inches, was sprayed inside on the wood and wire with an atomizer containing a 2 per cent solution of 98 per cent DDT in kerosene, after which it remained in the laboratory until no kerosene odor was perceptible. Various lots of bees were placed in this cage at monthly intervals and were fed sugar sirup from a vial that did not come in contact with the treated surface. They were left continuously in the cage, the dead being removed after each observation. All died within 12 hours on each trial for the first 3 months after the cage was sprayed. At the end of 5 months, 114 bees were dead after 24 hours, but 5 were alive although jittery. Seven months after the cage was treated, only 4 bees had died within 12 hours, and 50 per cent were still alive on the seventh day after being caged.

As a Contact Poison in Dust Form—Thirty bees were placed in each of three screened cages and were dusted through the screens with 1, 2, and 3 per cent concentrations of DDT, respectively. Those in cages 1 and 3 fanned the dust vigorously. Those in cage 2 started to sting each other immediately, and soon 13 of them had been stung to death. The cages were then supplied with sugar sirup through the screens. Bees in cages dusted with 2 and 3 per cent DDT began tumbling about within a few hours, and all were dead in less than 15 hours. Fifty per cent of those in cage 1 had died after 24 hours; but the remainder lived for a week, when the observations were discontinued.

Without cleaning of the cages, additional bees were placed in cages 2 and 3 after the dead were removed. They remained normally active, revealing no injury for 7 days, when the observations were stopped. Other cages were dusted in like manner with the same toxic effect, but the bees did not exhibit such antagonism toward each other as in the first trial with cage 2.

About 300 bees on one side of a broodless comb were liberally dusted with 2 per cent of DDT, after which the frame and the bees were returned to the hive in a closed super above a ventilated honeyboard. The bees showed no antagonism when dusted. Twenty-four hours later only 8 were found dead on the escape board. Later, the bees in two 3-frame nuclei and in one 10-frame colony were liberally dusted with 2 per cent DDT, care being taken to get some of the dust on sealed brood and in the cells of unsealed brood of one comb in each hive. After 24 hours there was no apparent mortality of the adults, although some injured bees may have left the hives and become concealed in the grass. The younger larvae had disappeared, but at least a majority of the older larvae were present, and their cells were later sealed over.

Eight grams of 3 per cent DDT was shaken over the tops of the frames of a colony, including one side of a comb containing both sealed and unsealed brood as well as over the bottom board and at least 200 bees thereon. By the following morning about 100 bees were on the ground in front of the hive, either dead or permanently down and kicking. The dust had been fanned from the bottom board, but some was still present in the cells. All younger larvae had been removed, but some older larvae were present. No additional dead were found the following day, and the colony was not permanently injured.

A quantity of 20 per cent DDT (GNBA) was dusted on to the entrances of three 3-frame nuclei and quite liberally over most of the bees in a colony that covered only three frames. The dust was shaken over the queen and bees in this colony, over the tops of the frames, into the cells of a small patch of unsealed brood, and over the alighting board. The field bees hesitated to enter their hives, but soon dropped down into the dust and either crawled in immediately or fanned their wings a short while before entering. Particles of dust clung to their feet and bodies, especially to those that fanned their wings. The bees in the regular 10-frame hive into which the dust had been shaken soon became disorganized, and robber bees gathered so rapidly that a wet cloth had to be placed over the entrance. Though the colony was guarding its hive again normally within 3 hours, the cloth was left in place until the next morning. Three hours after the dust had been applied to this colony, 20 dead or dying bees were removed from the bottom board beneath the frames. Several small and one large larva of the greater wax moth were noticed writhing on this board, which by now had become covered with the dust fanned by the bees from themselves and from their combs. When the hive was opened the bees showed considerable agitation, and the queen was being balled by a small group. Released from these, she appeared uninjured. As the hive was opened, three to four dozen bees tumbled or flew out onto the ground in front and ran jerkily away. They behaved differently from victims of arsenical poisoning, in that they did not hop or attempt to fly.

On the following morning, 20 dead or dying bees were found on the ground in front of the colony, and 14 were taken from the bottom board. All eggs and larvae had been removed from the cells. In front of the nuclei, 18 dead or dying bees were found on the ground. Those crawling and prone often curved their abdomens as if in the act of stinging. The bees within the nuclei appeared normal.

Forty-eight hours after the dust was applied, the queen and two workers were found dead on the bottom board of the colony, three other workers were paralyzed, and eight additional bees were dead or dying on the ground in front of the hive. No abnormal death rate occurred in the nuclei or in the colony beyond 48 hours after the dust was applied.

DDT Added to Queen-Cage Candy.—Measured amounts of 98 per cent DDT were mixed with queen-cage candy and fed to bees in screened cages provided with vials of water. Since the bees could also get their feet on the candy and thus might possibly be affected by contact with the DDT through the feet, tests were

also made with the candy squeezed between two glass plates. The minimum lethal dose in this medium was not determined because of the difficulty of accurately mixing minute amounts of DDT in the candy.

Queen-cage candy containing 1, 2, and 4 per cent of DDT killed all bees within 12 hours, and most of them were incapacitated within 6 hours. They ran wildly about within a few minutes after eating, many stopping frequently to stroke their mouth parts. They fed readily, the presence of the poison having no apparent repellent effect. Concentrations ranging from 1,000 to 10,000 parts of sugar candy to 1 part of DDT also killed all bees within 48 hours.

When food containing 1 part of DDT to 8000 parts of candy was placed between glass plates one-eighth inch apart, as compared with candy with surface entirely uncovered, there was no significant difference in the death rate. Only two cages of 30 bees each were thus exposed—an insufficient number from which to draw definite conclusions.

Effect of DDT in Pollen.—A paste was made by mixing a thick sugar sirup with pollen collected in a pollen trap placed before the entrance of a hive. After 0.5 gram of 98 per cent DDT had been thoroughly mixed with 220 grams of this paste, the cake was divided, and half was given to each of two 3-frame nuclei that had brood in all stages. The paste was practically all consumed within the next 11 days, with no noticeable detrimental effect on the brood. No change was observable in the population of either nucleus, and daily observations revealed no injured bees, although some may have left the hive unobserved.

Two grams of 98 per cent DDT were mixed thoroughly in 200 grams of a pollen-soy bean paste and placed on the frames of colony 33, which covered 5 frames and had brood in 4 combs. Eight days later practically all of the paste had disappeared; and the colony covered 5 frames, with brood in 5 combs. No noticeable injury had resulted to the brood, and daily observations had not revealed any injured bees. The same dose was again given to this colony with no noticeable ill-effects, although the paste was consumed less readily than the first lot.

Four grams of 98 per cent DDT mixed in 200 grams of pollen-soy bean flour paste, was then given to another colony, which covered 8 frames and had brood in 5 combs. This colony continued healthy, with no observable injury to brood or bees.

Additional lots of the same preparation were given to colony 33 and to a colony that had not yet received any of the chemical. No injury was observed while the paste was being consumed.

DDT Suspended in Sugar Sirup.—In the first preliminary test, 0.5 gram of 98 per cent DDT was added to a 20 per cent sugar solution, mixed thoroughly, and allowed to stand overnight. Part of the clear liquid was decanted in the morning and placed in vial A, while the remainder was well shaken and poured into vial B. Both vials were covered with Indian Head cloth and inverted on the wire of separate cages of 30 bees each. Two bees died within 3 days in the cage fed the decanted material, whereas all 30 were dead within 12 hours in the cage fed from vial B. When caged bees were fed continuously on a preparation consisting of 0.025 gram of 98 per cent DDT suspended in 20 per cent sugar sirup, 60 per cent of them died within 24 hours, and all were dead within 48 hours.

Two cages of bees were fed by vial from a solution decanted from one made 2 months earlier in which 0.5 gram of 98 per cent DDT had been added to 100 cubic centimeters of 20 per cent sugar sirup. After 24 hours, the bees regurgitated the sirup; and after 72 hours 12 per cent had died in one cage, 24 per cent in the other.

DDT was next dissolved in 95 per cent alcohol, 0.1 to 0.4 grams of the chemical being used in every 100 cc of alcohol. Small quantities of this solution, containing a calculated weight of DDT, were then added to 20 per cent sugar solution to make the desired concentrations for feeding bees individually with micropipettes or from cloth-covered vials. The amounts of the alcoholic solution added to the sugar sirup were well within the tolerance of the honeybee to alcohol.

METHODS OF DETERMINING THE MEDIAN LETHAL DOSE.—In attempting to determine the amount of DDT in sugar sirup that would kill 50 per cent of the caged bees within 48 hours, two different methods of feeding were employed. First, individual bees were fed varying amounts of known concentrations of DDT in sugar

sirup and then immediately given access to 20 per cent sugar sirup. The individual cages were made from the regular Pinard nailless queen-mailing cages by dipping them in hot paraffin and fastening a queen-cell cup in each to hold the plain sugar sirup. The bees were collected by hand from the top super of a 3-story colony, an attempt being made to select bees that were between 2 and 4 weeks old. The bees were left without food until they were hungry enough to take sirup from the micropipettes. In the second method the 30 or more bees placed in each cage were fed sugar sirup containing known concentrations of DDT from a cloth-covered vial inverted on the screen of their cages. These vials were left in position 1 to 3 hours and then replaced with vials of sirup not containing DDT. The cages were filled with bees shaken into a box from the third story of a hive in which the brood was confined to the lower hive body. A small cup was used to transfer the bees from the box to the feeder cage.

Table 1.—Results of feeding bees collectively by vial on DDT in sugar sirup.

Proportions of DDT to Sugar Sirup (approx.)	Micrograms of DDT Per c.c.	Per Cent of Bees Dead Out of 30 per Trial			Bees Fed DDT During Specific Intervals				
					Number of bees	Time fed, hours	Micrograms per cc	Per cent dead	
		24 hours	48 hours	72 hours				24 hours	48 hours
1– 4300	250.0	100			30	1	320	53	53
1– 6000	166.6	100			57	2	320	37	37
1– 6000	166.6	100			55	2	240	14	14
1– 12000	83.3	100			55	2	240	5	5
1– 12000	83.3	100			74	2	160	4	4
1– 28000	38.5	20	80	80	52	2	160	5	5
1– 28000	38.5	100			60	2	80	0	0
1– 28000	38.5	100			66	2	80	0	0
1– 28000	38.5	100			30	2	160	75	75
1– 28000	38.5	100			30	1	160	38	38
1– 55000	19.2	40	74	74	60	2	160	46	48
1– 55000	19.2	53	66	66	30	2	160	70	70
1– 55000	19.2	40	59	93	29	2	160	51	51
1– 55000	19.2	26	60	100	66	2.5	80	77	77
1– 73000	13.7	46	50	50	64	3	80	96	96
1–108000	11.0	0	0	6	49	3	80	87	87
1–108000	11.0	0	3	3	41	3	40	57	57
1–108000	11.0	0	3	3	52	3	80	94	94

The DDT was thrown into suspension when an alcoholic solution was added to the sugar sirup, but there seemed to be no significant precipitation of the material during the short time required to feed the bees by vial or by individual pipettes. The bees readily sucked the sugar sirup from the pipettes and through the cloth covers of the vials. In either case there was no way to determine how much honey they had in their stomachs before feeding on the sugar sirup. Presumably, each would more nearly fill its honey stomach when feeding from the vials than when fed by pipette, and a cumulative effect would result from continuous feeding. It was found that each would take 0.025 to 0.03 cubic centimeter quite readily and that an occasional bee would consume 0.04 cubic centimeter or more. There, however, was no way of ascertaining how much each would take from the vials, or whether all bees would take the poisoned sirup within the 1- or 3-hour period it was made available, or whether bees in the common cages fed others the sirup they had taken from the vials.

Sirup containing 20 per cent of sugar was used because, with micropipettes, more of it could be delivered, with greater accuracy, than when the viscosity was increased. Sugar sirup placed in the open cell cups of the individual cages soon became more and more concentrated, because of evaporation. Fresh sirup was added to each cage every morning. The individual cages were not supplied with additional water, since there was no significant death rate of the check bees dur-

ing the limited period each set of bees was observed.

Bees were selected at first from the guards at the entrance of a hive, but this source did not provide a sufficient number within a reasonable time. As a general rule, most of the cages were provisioned in the morning with bees from the top super of a 3-story hive. These proved more uniform in age and in willingness to take sugar sirup than similar bees later in the day, especially when the colony was gathering nectar.

Table 2.—Results of feeding individual bees known quantities of DDT.

Number Bees Fed	Micrograms DDT Per Bee	CC Fed Per Bee	Per Cent Dead in 24 hours	Per Cent Dead in 45 hours
30	2.0	0.025	10	10
31	2.0	0.025	6	6
31	2.4	0.03	16	16
30	2.4	0.03	70	70
32	2.4	0.03	12	12
30	2.4	0.03	33	33
31	3.2	0.04	83	83
20	3.2	0.04	55	55
31	3.2	0.02	48	48
30	3.8	0.02	23	23
30	3.8	0.02	20	23
32	4.0	0.025	96	96
32	4.0	0.03	56	56
30	4.0	0.025	46	53
30	4.0	0.04	20	20
30	4.0	0.04	23	33
30	4.0	0.02	26	26
30	4.0	0.02	33	33
30	4.4	0.02	36	36
30	4.4	0.02	30	30
32	4.8	0.03	79	79
31	4.8	0.03	36	38
31	4.8	0.03	93	93
32	4.8	0.03	93	93
31	4.8	0.03	38	38
31	4.8	0.03	48	48
30	5.0	0.025	53	53
30	5.0	0.025	46	50
30	5.0	0.025	46	46
30	5.0	0.025	63	63
31	6.4	0.04	70	70
30	6.4	0.04	93	93
16	6.4	0.04	81	81

DISCUSSION. When caged bees received only sugar sirup containing DDT for periods of 3 days, the median lethal dose was contained in a concentration of 13.7 micrograms of DDT per cc, or approximately 1 part of DDT to 73,000 parts of sugar sirup. A solution with 38.5 micrograms or more of DDT per cubic centimeter usually proved fatal to all within 24 hours, whereas weaker solutions were correspondingly less toxic. Table 1 further indicates that the exposure of caged bees to much higher concentrations for 1, 2, and 3 hours did not produce so high a mortality as continuous exposure to lesser concentrations. Since the death rate did not increase after the first 24 hours when bees were exposed to the sirup in common cages 1 to 3 hours, apparently not all the bees partook of the sirup or secured enough within that time to cause their death. Exposure for 3 hours to sugar sirup containing 40 and 80 micrograms of DDT per cubic centimeter resulted in greater injury than when larger concentrations were given for shorter periods. Obviously, to obtain results comparable with those secured by continuous exposure of the sirup, a different method of collecting the individual sample of bees will have to be resorted to, or the feeding period will have to be lengthened beyond the three hours.

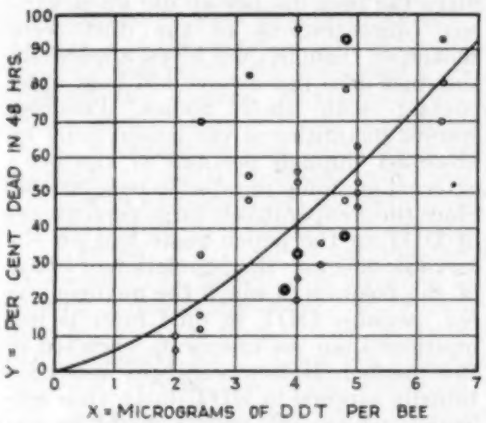


FIG. 1.—Tabulation of data to show the median lethal dose of DDT when fed in sugar sirup to honeybees.

Data secured by feeding individual bees known amounts of DDT in sugar sirup, as presented in table 2 and figure 1, indicate that the median lethal dose was 4.6 micrograms of the poison per bee. In general, if the bees survived the initial shock of the poison for 24 hours they lived be-

yond the third day. Observations, accordingly, were reduced from 72 hours to 48 in order to reduce possible error from the natural death rate. Since there seemed to be no connection between the volume of sirup given and the amount of DDT ingested, apparently a dilution of the sirup by the honey in the stomach or by feeding on plain sugar sirup after ingesting the poison did not affect the end results.

CONCLUSIONS.—The results confirmed previous reports that DDT acts both as a contact and as a stomach poison to bees. Since the bees did not all die when various concentrations of the dust were shaken on them in their hives, apparently the dust does not always kill bees upon contact with their bodies. Possibly, specific quantities of the poison must be absorbed through portions of the bee's external anatomy in order to be injurious. Since the comparatively large percentages of DDT in the pollen paste had no observable effect on the population or brood of the colonies to which the mixture was fed, perhaps DDT in dust form is less injurious than the arsenicals when fed in this manner. If, however, bees were continually exposed to DDT dusts while collecting pollen, the results might be entirely different from those indicated by these preliminary experiments.

Why the bees were killed by queen-cage candy containing small amounts of DDT, but not by pollen paste containing much larger quantities, cannot be explained until we know more about how the pollen paste is converted into food for adults and brood. Apparently DDT is less injurious than arsenicals when mixed in powdered form with pollen paste.

From the small amount of information available as to its effect on bees, if DDT should be used as carelessly as other insecticides are used at present, there is reason to believe that it might become more destructive than any other insecticide now known. Conceivably, however, its use and distribution might be more adequately regulated, so that only minimum amounts would be used to take the place of arsenicals; and the material might be confined to the plants treated and not applied when they are in bloom. Under these conditions its use might even lower the high mortality of bees now caused by promiscuous, inefficient, and unregulated application of millions of pounds of arsenicals. The beekeeping industry is doomed in those areas where arsenicals and other toxic substances are broadcast by airplanes and powered blowers without regard to the damage the drifting poisons might cause. The inclusion of one more chemical substance in such unregulated practices would simply bring total destruction to the beekeeping industry in a shorter time; and this catastrophe would force the development of more efficient equipment for applying insecticides, together with more adequate regulation of the distribution and use of the chemicals.

LITERATURE CITED

Annand, P. N. *et al.* 1944. DDT as an insecticide. JOUR. ECON. ENT. **37**(1): 125–59.

Holst, E. C. 1944. DDT as a stomach and contact poison for honeybees. JOUR. ECON. ENT. **37**(1): 159.

Filmer, R. S., and Chas. I. Smith. 1944. DDT as a contact poison for honeybees. JOUR. ECON. ENT. **37**(4): 537.

Hambleton, Jas. I. 1944. The new DDT a deadly foe to nearly all noxious insects gleanings in bee culture **72**(7): 332.

ORIENTAL FRUIT MOTH QUARANTINES

An intensive survey for the oriental fruit moth in the primary fruit areas of Arizona, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Washington, conducted in 1944 by the Federal Bureau of Entomology and Plant Quarantine, with the assistance of the States, resulted in the discovery of *Grapholitha molesta* (Busck) at the following towns and cities:

Denver, Grand Junction, LaJunta, Lamar and Mount Air in Colorado Nampa and Caldwell in Idaho and Ogden and Roy in Utah.

The States of Colorado and Utah thereupon established intrastate quarantines regulating the movement of host plants and fruits from the infested counties, and the State of Idaho revoked its quarantine pertaining to the fruit moth in other States.

An Unusual Outbreak of Aphids on Pine

C. H. HOFFMANN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

During the winter of 1943, and particularly in the spring of 1944, tremendous numbers of several species of aphids belonging to the genus *Cinara* were found feeding on different species of pine in North Carolina, South Carolina, and Virginia. Many infestations were discovered as a result of the copious amounts of honeydew, which were found deposited either on the trees or on the litter, soil, or other objects beneath the trees. Inquiries were received as to whether the aphids would permanently disfigure, weaken, or kill the pine trees, when the outbreak would subside, and what control measures would be effective in localities where the aphids had become a nuisance about dwellings because of their multitude and the great amount of honey dew they produced.

The finding of a heavy infestation of aphids on pine in the vicinity of Walhalla, S.C., in an area known to have many trees affected by little-leaf disease of pines (cause unknown), led forest pathologists and entomologists to consider the possibility that the aphids might be associated with this deterioration of pine, either as a vector of a possible virus pathogen or by causing a direct stunting of the growth. Later, as a result of surveys and information received from correspondents, it was found that heavy aphid infestations occurred in some areas where little-leaf disease existed, whereas the pines in other little-leaf areas were uninfested. Moreover, countless numbers of aphids were seen in forests well removed from any known area of little-leaf infection. It is likely, however, that the insects are not abundant in all localities every year. Nevertheless, the results of the survey fail to suggest that the deterioration is intimately associated with the insects.

A cursory examination of the literature indicates that very little has been written on the species of aphids encountered in this study. Hetrick (1940) observed large numbers of *Cinara taedae* Tissot feeding on the old needles of loblolly pine, *Pinus taeda* L., in July in Middlesex County, Va. He is of the opinion that the feeding causes a premature yellowing and shedding of the needles. McDaniel (1937) states that *C. strobi* (Fitch) sometimes causes considerable loss, particularly on young trees; and Felt (1938) found that this species was abundant enough to cause material injury to white pines in western Long Island, N.Y., and in southwestern Connecticut. *C. pini* (L.) is recorded as causing considerable injury to Scotch pine, especially to young trees, in Michigan (McDaniel 1937). There is a definite need for careful taxonomic, biological, and physiological studies to determine whether these and other species of *Cinara* are definitely associated with the decline of southern pine trees.

In the following account, notes are given on the distribution of these aphids in North Carolina, South Carolina, and Virginia for the year 1944. The aphid species and their tree hosts are also considered, as is the curtailment of infestations as a result of parasitization and the work of predators. Unless otherwise designated, all months given refer to the year 1944.

Apparently the outbreak of pine aphids in South Carolina was limited to the northwestern part of the State, north of a line from Anderson to Rock Hill. The aphids were most abundant from January through March and, according to some of the local residents, they occur in some numbers each year, but the amount of honeydew they deposited was greater in 1944 than ever before. A correspondent stated that this was the most serious outbreak in 14 years. During January at Walhalla the dropping of aphids from the trees onto woodsmen was annoying, and the honeydew was thick enough on the

[1] Many individuals assisted in the survey of this outbreak by making collections of specimens and submitting notes regarding infestations. The writer is indebted to the following members of the United States Department of Agriculture: G. H. Hepting and E. R. Roth, of the Bureau of Plant Industry, Soils, and Agricultural Engineering; R. F. Anderson and B. H. Wilford, of the Bureau of Entomology and Plant Quarantine; R. J. Seitz, of the Soil Conservation Service; E. M. Manchester, of the Forest Service; J. L. Huff, of the Timber Production War Project; and to J. A. Beal, of Duke University; L. A. Hetrick, of the Virginia Agricultural Experiment Station; W. C. Nettles, extension entomologist of South Carolina; and O. H. Phillips, county farm agent, Charlotte, N. C. The determinations were made by the Division of Insect Identification, of the Bureau of Entomology and Plant Quarantine, and I am grateful to P. W. Mason, C. F. W. Muesebeck, L. H. Weld, C. T. Greene, and M. R. Smith for identifications in their special groups.

leaves to cause them to stick to the men's shoes. Although a hard rain fell on the night of February 22, comparatively few aphids were dislodged from some of the shortleaf pines, as was evidenced when the trees were felled and examined the next morning. Some of them were heavily infested, particularly on the previous year's growth, with the aphids clustered at the bases of the needles. Other nearby pines, both seedlings and trees, were either lightly infested or uninfested. The species of aphids found feeding on pine included *Cinara* sp. (species unknown to P. W. Mason) on shortleaf pine, *Pinus echinata* Mill., and on pitch pine, *P. rigida* Mill.; *C. pini* was found on Virginia pine, *P. virginiana* Mill.; *C. strobi* on white pine, *P. strobus* L.; and *C. carolina* Tissot on Virginia pine. By the end of March the infestation had become greatly reduced, and it is believed that this was due primarily to parasitization by insects. Late in February large numbers of *C. carolina* were also found feeding on Virginia pine at Pickens.

According to an office record, *Cinara carolina* was taken on June 1, 1939, from slash pine, *Pinus caribaea* Morelet, in a plantation near Sumter, S.C. Most of the aphids were congregated and feeding on the twigs and main stems of trees, some of which appeared unhealthy and many of which had already died. Associated with the aphids were many ants, *Dorymyrmex pyramicus* (Roger), which attend plant lice on trees and also are highly predaceous, and an agromyzid larva, *Leucopis* sp., which is a predator of aphids. Considering the list of host trees given by Patch (1938, pp. 41–43) for these species of *Cinara*, it appears likely that the afore-mentioned occurrence of *C. pini* on Virginia pine and of *C. carolina* on Virginia pine and slash pine represent new tree-host records.

In North Carolina, late in February and early in March, *Cinara* sp. and *C. carolina* were found feeding on shortleaf pine at Brevard, *C. pini* on shortleaf pine (probably a new host record) at Mills River, and *Cinara* sp. on shortleaf and *C. carolina* on Virginia pine near Asheville. The infestations observed near Asheville were all light, and by April the colonies in one locality were confined to shortleaf pine trees less than 6 feet in height, which had been defoliated experimentally the previous fall. In another locality parasitization was evident during April, and two braconid wasps, *Aphidius*, n. sp., and *A. procephali* Ashm., and a cynipid wasp, *Charips* sp., were reared from the aphids. According to L. H. Weld (in correspondence), the only cynipid described from an aphid on pine in the United States is *C. lachni* (Ashm.) from Jacksonville, Fla. Late in March a light infestation of aphids was observed on pitch pine near Old Fort. The amount of honeydew deposited on the trees indicated a very heavy infestation of *C. carolina* on Virginia pine in the vicinity of Marion. A few colonies were observed at the bases of the needle fascicles, but most of the population had been parasitized. Both here and elsewhere it was observed that before dying the parasitized aphids had crawled out on the needles. The hymenopterous parasites were in the larval, pupal, and adult stages, mostly in the pupal stage. Many of the parasitized aphids were light colored. From 9 parasitized aphids placed in rearing, 8 adults of *Aphidius*, n. sp., and 1 *A. procephali* issued.

Vast numbers of aphids occurred in the pine stands of the Pisgah National Forest northwest of Morganton during February and March. One forester estimated that there was at least 1 aphid for each bundle of needles. Cruisers remarked that honeydew was so abundant on the pine forest litter that men wearing plain leather-soled shoes could travel with ease, even on the steeper slopes and in dry weather, as the honeydew caused the litter to stick to their shoes and prevented slipping. Both saplings and larger trees were infested, some of the trees being 16 inches in diameter at breast height. A careful examination of some of the heavily infested terminals failed to show any external signs that the aphid feeding was detrimental to the trees. Specimens collected from pitch, Virginia, shortleaf, and Table Mountain pine, *Pinus pungens* Lamb., were all identified as *Cinara* sp. This locality was visited on March 21 for the purpose of establishing an experimental plot wherein the effect of aphid feeding on pine-shoot growth could be studied. Unfortunately from this standpoint, the aphid infestation had subsided to the point where it was impracticable to make the study. Occasionally a small colony was found on a branch terminal,

but its numbers were usually being diminished by being preyed upon by several instars of syrphid larvae of the genus *Metasyrphus*. The large number of dead aphids (parasitized) on needles scattered throughout the tree branches was very conspicuous, and the author is of the opinion that parasites were largely responsible for the subsidence of the outbreak. Thirty-one parasitized aphids were isolated individually in the laboratory and within a week 31 braconid parasites, *Aphidius*, n. sp., emerged.

Pine aphids in exceptionally large numbers were also noted in the summer and until late in the fall of 1943, and again about the middle of February 1944 in Lincoln, Catawba, and Iredell Counties, N.C. They were also very abundant in Gaston County during February and March, as farmers reported that aphids on pines were more numerous in 1944 than they had been in 15 years. Specimens of aphids received from this county were identified as *Cinara* sp. In the forest they were being preyed upon by syrphid larvae, *Metasyrphus* sp. On May 10 the writer examined a Virginia pine plantation at Gastonia. Large numbers of dead aphids were found on the needles and practically all of them had a small hole in the body, indicating that they had been parasitized. Several reports showed that these insects were unusually abundant in Mecklenburg County. Apparently the population started to build up in October and November 1943, and attained epidemic proportions during the early part of 1944. A resident of Charlotte reported that millions of aphids were active on December 9, 1943, when the air temperature was 78° F., and that the street and his house were covered with them. Farmers throughout the area were concerned about the enormous amount of honeydew that was dripping from the pine trees, which they said was more noticeable this year than ever before. The aphids were so abundant that some people swept them up and burned them every night, to avoid the annoyance of getting them on themselves or into their homes. The most eastern aphid record for North Carolina was from Durham. This infestation started in November 1943 and was characterized by clusters of aphids on the shoots of pine and by the production of great quantities of honeydew. Except for brief periods following rainstorms, the honeydew deposit was prevalent throughout the winter months. Specimens collected from loblolly pine early in 1944 were identified as *C. carolina*. The aphids were reported to be more abundant this year than usual.

A report from Chatham, Va., stated that pine aphids, mostly *Cinara taedae* and a few *C. carolina*, were relatively abundant on Virginia pine during March 1944. Late in the autumn of 1943 there was an abundance of honeydew associated with pine trees. The occurrence of *C. taedae* on Virginia pine appears to be a new host record.—12-16-44.

LITERATURE CITED

Felt, E. P. 1938. Pine aphid (*Cinara strobi* Fitch). U. S. Bur. Ent. and Plant Quar., Insect Pest Survey Bul. 18(9): 614.

Hetrick, L. A. 1940. A pine aphid (*Cinara taedae*). U. S. Bur. Ent. and Plant Quar., Insect Pest Survey Bul. 20(7): 413.

McDaniel, E. I. 1937. Control of sucking insects on conifers. Mich. State Col. Ext. Bul. 175.

Patch, E. M. 1938. Food-plant catalogue of the aphids of the world including the Phylloxeridae. Maine Agr. Expt. Sta. Bul. 393.

DR. HAROLD H. SHEPARD

Dr. Harold H. Shepard on April 1, 1945 became Insect Toxicologist of the New York State College of Agriculture, Cornell University, Ithaca, New York. He succeeded Dr. Roy Hansberry who joined the staff of the Shell Development Company, Modesto, California in August, 1944. Dr. L. B. Norton, Insecticide Chemist formerly at the Geneva Experiment Station, is now stationed at Ithaca and will be associated with Dr. Shepard in insecticide research.

Dr. Shepard was for some years on the staff of the University of Minnesota at University Farm, St. Paul, but had been on leave of absence to work with the Office of Materials and Facilities, War Food Administration in Washington, D. C., since July 1943.

Occurrence and Distribution of Mosquitoes in Mississippi

ALLAN G. PETERSON[1] and WILLIAM W. SMITH[1]

During the past three years more intensive mosquito collection work has been carried on in Mississippi than ever before. In connection with malaria control activities, U. S. Public Health Service Malaria Control in War Areas personnel, under the direction of the Mississippi State Board of Health, have conducted extensive mosquito inspection work in the vicinity of 22 war areas including 67 war establishments. As these areas are widely distributed over the entire state, the numerous mosquito collections made from May 1, 1942, until September 1, 1944 should give reliable indications concerning the importance and distribution of the various species in the state. These records are based on adult collections from natural and artificial resting places, larval collections, light trap collections, and biting collections. The collections have included nearly every species previously reported from the state, and also *Aëdes cinereus* Meig. which is reported here for the first time as occurring in Mississippi.

Fifty-two species of mosquitoes are now known to occur in the state. These are listed and their distribution and abundance indicated. Brief general notes on each species include information on the abundance, distribution, and observed larval habitat. The localities where each species has been collected are listed from Malaria Control in War Areas records except where otherwise indicated.

Aëdes aegpti (L.). This domestic species widely distributed over the state and is most common during the months from July to November. It is abundant in most of the heavily populated areas of the state. Larvae are common in the water standing in tin cans, rain barrels, old cisterns, and similar places. Collections: Aberdeen, Biloxi, Centreville, Clarksdale, Columbus, Greenville, Grenada, Gulfport, Hattiesburg, Jackson, Laurel, McLaurin, Meridian, Moss Point, Pascagoula.

Aëdes atlanticus D. & K. This species occurs generally over the southern half of the state. Adults were abundant around Gulfport in wooded sections in 1942, but scarce in 1943 and 1944 due evidently to dry weather. They are most abundant in August and September, but specimens have been taken in all months from March through September. Collections: Biloxi,[6] Centreville, Flora,[6] Grenada, Gulfport Hattiesburg, Jackson, Madison,[4] Meridian, Picayune.

Aëdes canadensis (Theob.). Larvae of this species are commonly found in temporary pools during the winter and early spring over a large part of the state. Apparently there is only one generation each year, as adults have been found only in the spring. The species has not been found to be a troublesome biter. Collections: Biloxi, Camp McCain, Camp Shelby,[5] Centreville, Columbus, Greenville, Greenwood, Gulfport, Henderson Point, Jackson, Meridian.

Aëdes cinereus Meig. This species has been found only at Flora, where larvae were in flood water pools near Big Black River in early spring along with *A. vexans*. Collection: Flora.

Aëdes duprcei (Coq.). Specimens are not common but are widely distributed in the state, having been found in all except the northeastern section from May through October. Most specimens have been taken in light traps. Collections: Camp Shelby,[4] Columbus, Greenville, Greenwood, Gulfport,[6] Jackson,[4] Laurel.

Aëdes fulvus pallens Ross. This rare woods species is probably quite widely distributed in the state. A few specimens have been taken in light trap and biting collections. Collections: Hattiesburg, Mileston.

Aëdes grossbecki D. & K. The only recent specimen was reported to have been taken in a light trap at Camp Shelby in June, 1943,[5] Older records include specimens from Natchez and Scott.[3]

Aëdes firmatus D. & K. Adults of this species have been collected in small numbers in most regions in the state except the northeastern section. They occur from March through September, probably being most abundant in June. Collections: Biloxi, Camp McCain, Centreville, Greenville, Gulfport, Hattiesburg, Jackson, Madison,[4] Meridian, Mileston.

[1] Assistant Sanitarian (R), U. S. Public Health Service, Malaria Control in War Areas, State Board of Health, Jackson, Mississippi.

Aëdes mitchellae (Dyar). This species has been taken chiefly from Jackson southward in the state. Larvae have been found in ditches along with those of *A. atlanticus*. Adults have been collected in light traps and biting stations for the most part. Adults were fairly common in woods near Picayune in May. It is most abundant in the spring and fall, but has been found from January to December. Collections: Biloxi, Centreville, Greenville, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel,[6] Picayune.

Aëdes sollicitans (Walk.). This common salt marsh species is found on the Gulf Coast and inland at Jackson and several other localities. It is locally and seasonally abundant on the Gulf Coast, and only a few specimens have been found inland to the present time. Larvae have been found near Jackson in salt water being discharged from gas wells. Collections: Biloxi, Camp Shelby,[2] Greenville,[2] Grenada, Gulfport, Henderson Point, Jackson, Pascagoula.

Aëdes sticticus (Meig.). This mosquito has been a common pest and severe biter in wooded areas during the spring and early summer. It is widely distributed over the state. As a pest, it is locally and seasonally abundant. Larvae have not been collected, but probably occur in flood waters. There appears to be only one generation per year. Collections: Biloxi, Clarksdale, Columbus, Flora, Greenville, Greenwood, Grenada, Hattiesburg, Jackson, Laurel, Meridian, Picayune.

Aëdes stimulans (Walk.). Although this northern species has been collected once at Electric Mills,[2] there are no recent records of its occurrence in the state.

Aëdes taeniorhynchus (Wied.). This species has about the same range on the Gulf Coast as *A. sollicitans*. It is most abundant during late summer and early fall and was a local pest in Jackson during those seasons in 1943. Breeding in Jackson occurs in salt water from old gas wells near the eastern city limits. Collections: Biloxi, Clinton,[2] Gulfport, Hattiesburg,[2] Henderson Point, Jackson, Pascagoula.

Aëdes thibaulti D.&K. Although rather uncommon, this species is probably widely distributed over the state. It occurs in the spring and is said to breed in stump holes. Collections: Columbus, Greenville, Grenada, Hattiesburg, Jackson, Laurel, Meridian.

Aëdes tormentor D. & K. No attempt has been made by the authors to separate *Aëdes tormentor* from *Aëdes atlanticus*. However, Dr. Mike Wright reported this species as common in the Gulfport area in September, 1942. His material was taken from light traps. (Unpublished USDA records).

Aëdes triseriatus (Say). Although widely distributed, this species is not very abundant in Mississippi. The larvae are found in tree holes in association with the larvae of *Orthopodomyia signifera*, *Megarhinus septentrionalis*, and *Anopheles barberi*. Collections: Biloxi, Centreville, Columbus, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Jackson, Laurel.

Aëdes vexans (Meig.). This mosquito is a common woods species found throughout the state and locally abundant enough to be a pest. It is common in spring and fall. Larvae are abundant in temporary rainwater pools and are frequently associated with larvae of *Psorophora* spp. Collections: Biloxi, Centreville, Clarksdale, Clinton, Columbus, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel, Madison, Meridian, Mileston, Pascaguola, Sherard.

Anopheles atropos D. & K. Adults of this species have been taken in light traps, resting stations, and biting collections on the Gulf Coast. It is most abundant in spring and fall. It was locally abundant at Henderson Point during February, March, and April in 1943 and 1944. Collections: Biloxi, Gulfport, Hattiesburg,[2] Henderson Point.

Anopheles barberi Coq. This tree hole mosquito is widely distributed over the state, but never very abundant. The larvae are found in tree holes in association with larvae of *Orthopodomyia signifera*, *Megarhinus septentrionalis*, and *Aëdes triseriatus*. First instar larvae were collected throughout the winter in 1943. Collections: Aberdeen, Camp McCain,[8] Centreville, Clinton, Columbus, Gulfport, Hattiesburg, Jackson, Laurel, Madison.

Anopheles bradleyi King. This salt or brackish water breeding *Anopheles* is rather common on the Gulf Coast, especially in the vicinity of Biloxi. Collections: Biloxi, Camp Shelby,[8] Gulfport, Henderson Point.

Anopheles crucians Wied. This an-

opheline is widely distributed over the entire state, but is seldom abundant except on the Gulf Coast and at Picayune where it occurs in large numbers in the spring. Larvae and adults have been found during the coldest months of the year. The larvae in the spring months are often associated with those of *Culex restuans*. Collections: Biloxi, Brookhaven, Camp McCain, Camp Shelby, Centreville, Clarksdale, Clinton, Columbus, Como, Flora, Gautier, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel, Madison, Meridian, Moss Point, Pascagoula, Picayune, Prairie.

Anopheles georgianus King. This uncommon species has been collected only in the southern part of the state where the larvae occur in seepage areas. Collections: Biloxi, Camp Shelby,[4] Laurel.[6]

Anopheles pseudopunctipennis Theob. Although this species has been reported from a number of counties in central Mississippi,[1,5] there are no recent records of its occurrence in the state.

Anopheles punctipennis (Say). This mosquito is common throughout the state. The larvae frequently prefer the margins of streams and ditches. However, in the spring and fall during the periods of greatest abundance, the larvae are frequently associated with those of *A. quadrimaculatus*. Collections: Aberdeen, Biloxi, Centreville, Clarksdale, Clinton, Columbus, Como, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Jackson, Laurel, Madison, McLaurin, Meridian, Moss Point, Pascagoula, Picayune, Prairie, Starkville.

Anopheles quadrimaculatus Say. The "malaria mosquito" is common throughout the state and frequently occurs in great numbers, especially during the early summer. It is usually most abundant in the delta region in the northwestern part of the state. Larvae are frequently associated with the larvae of *Culex erraticus* and *Uranotaenia sapphirina*. Larvae have been found from March to December, and adults have been collected throughout the year. A comparatively small number of fertilized over-wintering females carry the species through the winter. Collections: Aberdeen, Ackerman, Biloxi, Belzoni, Brookhaven, Centreville, Clinton, Clarksdale, Columbus, Como, Drew, Flora, Gautier, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Indianola, Jackson, Lake Washington, Laurel, Leland, Madison, Meridian, Moss Point, Pascagoula, Picayune, Prairie, Starkville, Vicksburg.

Anopheles walkeri Theob. This is a rare species which has been collected only at Camp Shelby in light traps.[4]

Culex apicalis Adams. This species is widely distributed and abundant in the state. The larvae are common in most areas during the winter and spring along with larvae of *Culex restuans*. Collections: Biloxi, Centreville, Clarksdale, Clingon, Columbus, Como, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Jackson, Laurel, Madison, Meridian, Pascagoula.

Culex erraticus D. & K. This mosquito is very common throughout the state during spring, summer, and fall. Adults are very abundant before they become important as pests. The larvae are associated with those of *Anopheles quadrimaculatus* and *Uranotaenia sapphirina*. Collections: Aberdeen, Ackerman, Biloxi, Centreville, Clarksdale, Clinton, Columbus, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Jackson, Laurel, Madison, Meridian, Moss Point, Pascagoula.

Culex nigripalpus Theob. Although never found abundantly, this species is widely distributed over the state and has been taken chiefly as larvae associated with *C. salinarius*. Collections: Biloxi, Centreville, Clinton, Columbus Air Base,[6] Greenville, Gulfport, Henderson Point, Laurel, Madison.

Culex peccator D. & K. This rare species has not been recorded by Malaria Control in War Areas personnel in Mississippi, but has been reported in unpublished army records as occurring at Camp McCain, Centreville, and Clinton.[8] The larvae are usually found in about the same type of habitat as *C. erraticus*.

Culex pilosus (D. & K.) Fairly large numbers of larvae have been found in the southern part of the state in June and September. One adult was taken in a resting station at Columbus.[4] Collections: Biloxi,[6] Camp Shelby,[4] Columbus,[4] Gulfport, Meridian,[6] Pascagoula.

Culex pipiens L. The presence of this species has been established in the northern part of the state. Collections: Como.[7]

Culex quinquefasciatus Say. The southern house mosquito is widely distributed

and probably the most common species in the state. Larvae occur under a wide variety of breeding conditions, but are usually most abundant in polluted water. This species is most abundant during the summer and fall, but both larvae and adults can be found practically throughout the year. Collections: Aberdeen, Biloxi, Brookhaven, Centreville, Clarksdale, Clinton, Columbus, Como, Flora, Gautier, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Indianola, Jackson, Laurel, Madison, Meridian, Moss Point, Pascagoula, Picayune, Prairie.

Culex restuans Theob. This is a common mosquito but never important as a pest. It is widely distributed throughout the state, being abundant through spring and fall. Larvae occur throughout the winter, at least in the southern half of the state. Collections: Biloxi, Centreville, Clarksdale, Clinton, Columbus, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel, Madison, Meridian, Pascagoula, Picayune, Prairie.

Culex salinarius Coq. This is probably the most abundant and widespread *Culex* in the state with the exception of *C. quinquefasciatus*. Many specimens have been taken in light traps during the spring, summer and fall, especially on the Gulf Coast. They were abundant and serious pests at Henderson Point in the spring of 1943 and 1944. Collections: Biloxi, Camp Shelby, Centreville, Clarksdale, Clinton,[6] Columbus, Como, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel,[6] Madison, Meridian, Pascagoula.

Culex tarsalis Coq. This species has been found widely distributed in the state but not abundant in any locality. Larvae have been found only at Camp Shelby, and adults elsewhere. Collections: Biloxi, Grenada, Camp Shelby,[6] Centreville,[6] Clarksdale, Clinton,[6] Como,[6] Flora,[6] Greenville, Greenwood,[6] Gulfport,[6] Laurel,[6] Meridian.

Culiseta inornata (Will.). Larvae and adults of this species have been collected chiefly during the cooler months from September through May. They are found in considerable numbers throughout the state. Larvae are often associated with *Culex restuans*. No specimens have been found in July or August in the state. Collections: Biloxi, Centreville, Clarksdale, Columbus, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel, Meridian, Pascagoula, Prairie, Tchula.

Culiseta melanura (Coq.). Like *C. inornata*, this species is found only during the fall, winter, and spring months. It is considerably less abundant than *C. inornata* although about as widespread in its distribution in the state. Collections: Biloxi, Camp McCain,[4] Camp Shelby,[4] Centreville,[6] Clinton,[6] Columbus,[4] Flora, Greenville, Greenwood, Gulfport, Jackson,[4] Meridian.[6]

Mansonia perturbans (Walk.). This mosquito is widely distributed in the state, but uncommon. Adults occur from May until October; however, most adults have been collected during May, June, and July. The larvae, which occur on the roots of aquatic plants, have not been collected. Collections: Biloxi, Camp Shelby,[4] Centreville, Clarksdale, Columbus, Gulfport, Jackson, Laurel, Madison.

Megarhinus septentrionalis D. & K. This is one of the tree hole breeders usually found in association with *Anopheles barberi*, *Orthopodomyia signifera*, and less frequently with *Aëdes triseriatus*. This species is widely distributed but not abundant in the state. Larvae have been found in tree holes at Jackson throughout the winter, but were rare during the dry summer of 1943. Collections: Camp Shelby,[8] Centreville, Greenville, Greenwood, Gulfport, Jackson.

Orthopodomyia alba Baker. One larva of this species was recorded from Camp Shelby.[6]

Orthopodomyia signifera (Coq.). This tree hole species is widely distributed in the state but not abundant. The larvae are found in tree holes in association with larvae of *Anopheles barberi*, *M. septentrionalis*, and *Aëdes triseriatus*. Observations have shown that this species overwinters in the larval stage in the vicinity of Jackson. Collections: Biloxi, Centreville, Greenville, Greenwood, Hattiesburg, Jackson, Laurel, Madison, Meridian.

Psorophora ciliata (F.). This large species is widely distributed and fairly common during the spring and summer. The predaceous larvae are found in temporary rain pools in association with larvae of *P. confinnis* and *Aëdes vexans*. Collections: Biloxi, Centreville, Clarksdale, Green-

ville, Greenwood, Grenada, Gulfport, Hattiesburg, Jackson, Laurel, Madison, Pascagoula.

Psorophora confinnis (Lynch-Arribalzaga). This species is well distributed and quite a common pest over the entire state. Larvae occur in great numbers in temporary rain pools. The adults are usually most abundant from June to October. Collections: Biloxi, Centreville, Clarksdale, Clinton, Columbus, Como, Flora, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Jackson, Laurel, Madison, Meridian, Pascagoula.

Psorophora cyanescens (Coq.). This mosquito appears to be widely distributed in the state and locally abundant as a pest. Adults were common pests in the vicinity of Clarksdale in 1942 and in Greenwood in 1943. Larvae occur in temporary rain pools in association with larvae of *P. confinnis*. The species is most abundant from June to September. Collections: Biloxi, Clarksdale, Greenwood, Hattiesburg, Meridian.

Psorophora discolor (Coq.). Occurring most abundantly in the summer and fall in temporary pools and rain-flooded ditches, this species is present over most of the state and has been taken in considerable numbers chiefly as larvae. Collections: Centreville, Clarksdale, Clinton, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Jackson, Laurel, Madison, Pascagoula.

Psorophora ferox (Humb.). This white-footed woods species is one of the most widespread and abundant *Psorophora* found in the state. It is present in practically all of the wooded river bottom lands, and it is a vicious biter during the spring, summer, and fall. Collections: Centreville, Clarksdale, Clinton, Columbus, Flora, Greenville, Grenada, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel, Madison, Meridian, Pascagoula.

Psorophora horrida (D. & K.). Often associated with *P. ferox* and *Aëdes sticticus* this species may easily be mistaken for *P. ferox* in the woods. It has been recorded in the state chiefly during the spring as adults. Collections: Biloxi, Camp McCain,[5] Camp Shelby,[6] Clinton, Flora, Greenville, Jackson, Meridian.

Psorophora howardii (Coq.). This uncommon species, which closely resembles *P. ciliata*, is widely distributed in the central and southern parts of the state. Specimens have been found from May to September. The larvae are predaceous and occur in temporary rain pools. Collections: Biloxi, Centreville, Flora, Greenwood, Hattiesburg, Jackson, Laurel, Pass Christian.

Psorophora varipes (Coq.). This mosquito is widely distributed but only locally abundant. During June floods it has been abundant in the vicinity of Jackson and a severe pest in the vicinity of Greenville. The species is frequently associated with *Aëdes sticticus* and *P. ferox*. Collections: Centreville, Clinton, Flora, Greenville, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel, Madison, Meridian.

Uranotaenia lowii Theob. This small species is fairly well distributed over the state but is rarely taken in numbers except on the Gulf Coast. It is usually taken in light traps, and is recorded as being most abundant during August, September, and October. Collections: Biloxi, Camp Shelby,[4] Centreville,[6] Clinton,[6] Columbus,[4] Flora,[4] Greenville, Gulfport, Hattiesburg, Henderson Point, Jackson,[4] Laurel,[6] Madison,[4] Meridian.

Uranotaenia sapphirina (O.-S.). Found usually in pools filled with green vegetation, this species is frequently associated with *Anopheles quadrimaculatus* and *Culex erraticus*, especially during the summer and fall when it is most abundant. Adults have been found overwintering in considerable numbers in hollow trees together with *A. quadrimaculatus* and *A. punctipennis*. They are common over the entire state. Collections: Biloxi, Centreville, Clarksdale, Clinton, Columbus, Greenville, Greenwood, Grenada, Gulfport, Hattiesburg, Henderson Point, Jackson, Laurel, Madison, Meridian, Pascagoula.

SUMMARY.—Recent intensive mosquito collection work has increased to 52 the number of species of mosquitoes known to occur in Mississippi. Brief notes are presented concerning the distribution and the observed larval habitat of each species.

[1] Carley & Balfour 1929.
[2] Carpenter & Middlekauff 1944.
[3] King *et al.* 1944.
[4] King *et al.* 1943.
[5] Kumm 1929.
[6] Middlekauff & Carpenter 1944.
[7] Wanamaker *et al.* 1944.
[8] U. S. Army records.

LITERATURE CITED

Carley, P. S., and M. C. Balfour. 1929. Prevalence of malaria in Humphreys and Sunflower Cos., Mississippi in 1927–28. So. Med. Jour. 22: 377–382.

Carpenter, S. J., and W. W. Middlekauff. 1944. Inland records of salt marsh mosquitoes. JOUR. ECON. ENT. 37(1): 108.

King, W. V., G. H. Bradley, and T. E. McNeel. 1944. The mosquitoes of the southeastern States. U.S.D.A. Misc. Pub. No. 336.

King, W. V., Louis Roth, James Toffaleti, and W. W. Middlekauff. 1943. New distribution records for the mosquitoes of the southeastern United States during 1942. JOUR. ECON. ENT. 36(4): 573–77.

Kumm, H. W. 1929. The geographical distribution of the malaria carrying mosquitoes. Amer. Jour. Hyg. Monog. 10.

Middlekauff, W. W., and S. J. Carpenter. 1944. New distribution records for the mosquitoes of the Southeastern United States in 1943. JOUR. ECON. ENT. 37(1): 88–92.

Wanamaker, J. F., R. W. Chamberlain, and S. J. Carpenter, 1944. Distribution of *Culex pipiens* in the southeastern United States. JOUR. ECON. ENT. 37(1): 106–7.

Effect of Nicotine Applied with Calcium Arsenate at Different Times of Day Upon Cotton Aphids and Yields

M. T. YOUNG, G. L. SMITH, G. L. GARRISON, and R. C. GAINES, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Previous reports (Young *et al.* 1942b and 1943) have shown that increases in populations of the cotton aphid, *Aphis gossypii* Glov., can be prevented by the addition of nicotine to the calcium arsenate used for control of the boll weevil, *Anthonomus grandis* Boh. Information is summarized in this paper on the effect upon aphid infestations and upon cotton yields of calcium arsenate-nicotine applied at various times of day.

Applications of mixtures of calcium arsenate and nicotine were made in six experiments in the early morning (between daybreak and 8 a.m.) and late in the afternoon (between 6 p.m. and dark), and in a single experiment at midday (between 1 and 3 p.m.). Plot sizes and arrangements, as well as the methods used in making insecticide applications, insect infestations, and cotton yields, have already been discussed.

A summary of the records made in six replicated experiments during the period 1941 to 1944 is given in table 1. The calcium arsenate-nicotine mixtures contained 0.5 per cent of nicotine in the 1941 experiment and either 1 or 2 per cent of nicotine in the remaining experiments. The 0.5 and 1 per cent mixtures were used in all applications, and the 2 per cent mixtures in alternate applications with calcium arsenate alone. Nicotine sulfate, free, or fixed, was used in preparing the mixtures, but in each experiment the same form of nicotine was compared in applications made at different times of the day. In all experiments except those in 1941, where only early-morning applications were made, plots were dusted with calcium arsenate alone at the same times of day that the plots were treated with the calcium arsenate-nitotine mixtures. The effects of calcium arsenate applied at different times of day upon boll weevil control have already been presented (Young *et al.* 1942a). In each of the experiments other treatments were included, but only the treatments pertinent to this study are used in the summary.

The results in different experiments varied greatly. Midday applications of calcium arsenate-nicotine gave no appreciable control of aphids in the one experiment where this treatment was used. In five of the six experiments the smallest numbers of aphids developed following late-afternoon applications. Late-afternoon applications of calcium arsenate-nicotine mixtures gave average increases of 312 pounds of seed cotton per acre over no treatment and 286 pounds over calcium arsenate alone. Early-morning applications gave average increases of 187 pounds over no treatment and 161 pounds over calcium arsenate alone. Late-afternoon applications of calcium arsenate-nicotine mixtures gave an average increase over early-morning applications of 125 pounds per acre, which is a substantial gain but is within the limits of experimental error.

Table 1.—Effect of calcium arsenate-nicotine applied at different times of day, on cotton aphids and yields of cotton.

Year and Treatment	Applications	Dosage per Acre	Boll Weevil Punctured Squares	Aphids per Square Inch		Seed Cotton per Acre
				Final Count	Seasonal Average	
	Number	*Pounds*	*Per Cent*	*Number*	*Per Cent*	*Pounds*
1941						
Check	—	—	63	26.4	21.8	972
Calcium arsenate	6.5	6.9	38	61.2	40.9	1,008
Calcium arsenate+nicotine:						
Early morning	6.5	8.0	34	62.3	32.5	1,062
Late afternoon	6.6	6.8	40	38.1	18.5	1,230
1942						
Check	—	—	30	13.5	5.1	2,012
Calcium arsenate	5.0	6.1	14	52.7	18.6	1,735
Calcium arsenate+nicotine:						
Early morning	5.0	6.1	12	18.2	6.4	2,070
Midday	5.0	6.4	17	39.6	14.1	1,776
Late afternoon	5.0	5.9	16	14.6	5.2	2,024
1943 (Expt. 1)						
Check	—	—	53	14.2	5.4	2,094
Calcium arsenate	5.0	7.0	36	27.3	16.4	2,013
Calcium arsenate+nicotine:						
Ealy morning	5.0	6.9	38	13.2	6.1	2,490
Late afternoon	5.0	7.6	42	9.4	4.4	2,598
1943 (Expt. 2)						
Check	—	—	70	2.1	1.1	1,111
Calcium arsenate	5.0	6.3	26	24.9	10.5	1,480
Calcium arsenate+nicotine:						
Early morning	5.0	6.6	25	2.8	1.0	1,520
Late afternoon	5.0	6.4	33	3.2	1.3	1,660
1944 (Expt. 1)						
Check	—	—	34	10.0	4.1	2,052
Calcium arsenate	5.0	6.3	29	34.2	13.7	1,905
Calcium arsenate+nicotine:						
Early morning	5.0	6.9	27	25.1	8.2	2,028
Late afternoon	5.0	6.5	32	6.8	2.9	2,430
1944 (Expt. 2)						
Check	—	—	63	1.9	.8	2,500
Calcium arsenate	5.0	6.1	44	8.0	3.5	2,753
Calcium arsenate+nicotine:						
Early morning	5.0	7.6	44	.5	.2	2,690
Late afternoon	5.0	7.5	53	.2	.1	2,670
Average 1941 to 1944						
Check	—	—	52	11.4	6.4	1,790
Calcium arsenate	5.2	6.4	31	34.7	17.3	1,816
Calcium arsenate+nicotine:						
Early morning	5.2	7.0	30	20.3	9.1	1,977
Late afternoon	5.2	6.8	36	12.0	5.4	2,102
Minimum significant difference	—	—	8	9.8	4.0	182

Literature Cited

Young, M. T., G. L. Garrison, and R. C. Gaines. 1942a. Boll weevil control with calcium arsenate applied at different times of day and at different time intervals. Jour. Econ. Ent. 35(4): 487–9.

Young, M. T., G. L. Garrison, and R. C. Gaines. 1942b. Calcium arsenate with and without aphicides for control of boll weevil and cotton aphid. Jour. Econ. Ent. 35(4): 490–2.

Young, M. T., G. L. Garrison, and R. C. Gaines. 1943. Calcium arsenate with and without cube and nicotine for control of the boll weevil and the cotton aphid, at Tallulah, La., in 1942. Jour. Econ. Ent. 36(6): 901–3.

Anopheles pseudopunctipennis[1] in the Los Chillos Valley of Ecuador

ROBERTO LEVI-CASTILLO,[2] *University of Guayaquil, Ecuador*

The Los Chillos Valley is located in the Province of Pichincha and extends from a region south of Quito about 30′ south of the equator to points a few miles north of the equator and from points slightly west of Quito, 79° 30′ west longitude, to points some 20 miles to the east of that city. The main hydrographical system is that of the Guallabamba River which arises as the San Pedro and continues with that name until it is joined by the Pisque and becomes a part of the Esmeraldas. Numerous small rivers of this region belong to the Guallabamba System. They arise as mountain streams and, during the rainy season, become large rivers but are, at other times, series of large pools left by the receding of the waters at the onset of the dry season. These pools soon become alive with the larvae of *Anopheles* and *Culex* mosquitoes. The average altitude of the region is about 2500 meters.

The highest point at which *Anopheles pseudopunctipennis* has been observed was 2500 meters, at Guangopolo; the lowest point was at Perucho, 1830 meters.

The main towns in this region, all formerly infested with the mosquitoes, with the elevation of each in meters, are shown in the following list:

Perucho	1830
Puellaro	2000
Tumbaco	2390
Guallabamba	2106
Cumbaya	2400
Chillogallo	2410
San Antonio	2423
Pomasqui	2507
Puembo	2584
Alangasi	2587
Sangolqui	2502
Pifo	2580
Guangopolo	2588
Conocoto	2525
San Pedro del Tingo	2500

BREEDING PLACES.—*Anopheles pseudopunctipennis* was found to be the main vector of malaria in the Los Chillos Valley region as it was the only anopheline mosquito present and it was often found in the houses after dark in large numbers. Specimens captured were often found to be engorged with blood and many of the females were found, upon dissection, to be naturally infected with the malarial organism. Further proof of the fact that this species was the vector of the disease in the locality was afforded by the observation that, after the elimination of the mosquito from the valley no new cases of malaria developed.

Anopheles pseudopunctipennis was found breeding in sunny pools left behind by the small rivers in the region during the dry season, in small bodies of water left in irrigating ditches by the crumbling of their banks, in hoof prints of the common domestic animals and even in the drains of the swimming pools of the summer resorts of San Pedro del Tingo and Alangasi where the mosquitoes were a cruel affliction to the swimmers after sunset.

The mosquito was always found breeding in pools where great quantities of *Spirogira* were growing along the margins. When the algae were removed the mosquitoes disappeared completely. The writer experimented with this phenomenon by placing glasses of water in cages. In one glass mosquito larvae were furnished with *Spirogira*, which served as food; in the other, no *Spirogira* was present. Mosquitoes developed normally in the glass provided with the *spirogira* while those without the algae pupated prematurely and produced sub-normal adults, or died before completing their development.

HABITS AND ECOLOGY.—*Anopheles pseudopunctipennis* is attracted more strongly to human blood than to that of animals. The mosquitoes were allowed their choice of feeding on the hand of the writer which was thrust into a cage, or on guinea pigs which had the hair removed from the abdomen and were tied in the cage. Seven out of ten mosquitoes were found to be engorged with human blood; only two with the blood of the guinea pig. This preference for human blood was forther proven by collecting mosquitoes in houses in the valley. White paper was

[1] Dr. Levi-Castillo considers the mosquito in this region to be a distinct variety which he has named "*rivadeneras*".—*Ed.*

[2] Sanitary Entomologist (Culicidologist) Department of Tropical Medicine.

spread on the floors and a spray of pyrethrum in kerosene was used to stupefy the mosquitoes which were then collected from the paper on which they had fallen. For morphological examination individual mosquitoes were sought out and captured with chloroform tubes because the kerosene spray rendered specimens unsuitable. For counts of the engorged individuals, the sprayed mosquitoes were satisfactory.

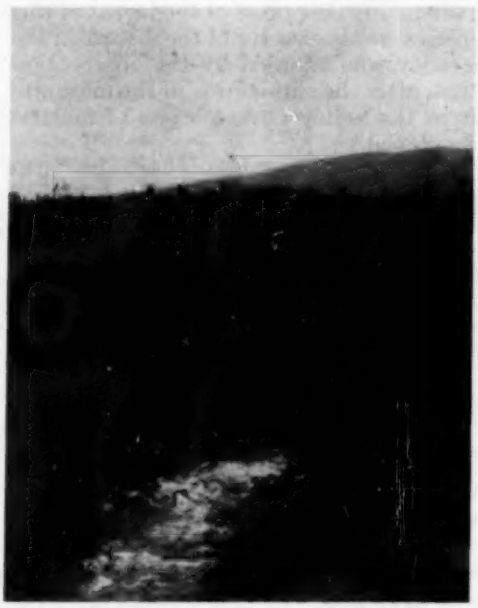


FIG. 1.—The San Pedro River which formerly provided many breeding places for the mosquito.

Dr. Rivadeneira devised a tent in which one or two men slept and served as human bait for the mosquitoes. A number of such tents were set near the rivers, and other known breeding places in order to attract the females and collect them when engorged or simply capture them by means of chloroform tubes to study their anthropophilic tendencies. Females were found inside the tents in direct relation to the distance from the breeding place but males were seldom found inside the tents. Females were usually captured in the morning on the upper part of the tent where they collected to digest the blood taken during the night and tents were so devised that, once inside, no mosquito could fly out. Total counts could thus be made the next morning in each tent.

LIMITS OF THE INFESTATION.—In the triangular section formed by the junction of the Pisque River with the Guallabamba, what was probably the original focus of the infestation was discovered. It seems likely that this section had been infested for at least 500 years as the mosquito seems to be a native of this highland region. Spread was partly due to the strong winds but was still very slow because of limited areas of suitable breeding conditions. Water was limited and much of that which was available lacked the *Spirogira* necessary for the development of the larvae. During the rainy season migration was impossible and the mosquitoes remained inactive in such shelter as was available. Possibly the destruction of adults by the beating rains and of the larvae by the flushing of the streams also tended to retard increase. After a long period of time, perhaps 300 years, the establishment of towns and other settlements in the region gradually extended the area where suitable feeding conditions were to be found and the mosquito extended slowly but surely from the Guallabamba region to other towns at elevations ranging from about 1800 meters to 2588 meters, at Guangopolo, the highest point at which the mosquito has been found. At higher elevations the evening temperature were too cold for the adults and the water was too cold at all times for the larvae which require water ranging from 18° C. to 20° C. The reaction, also, must be somewhat alkaline, pH 7.5 to 8.5. Beyond these limits, in either direction, no larvae were to be found. When larvae were taken by the writer by plane to his laboratory in Guayaquil and placed in water at about 22° to 24° C. they pupated but did not produce adults. The limited range in suitable breeding conditions was, from the outset, an advantage in the control of the species.

The spread of the mosquito into new areas proceeded slowly but surely; Tumbaco and Cumbaya, well to the south of the original infestation, became infested only about 80 years ago and the rest of the valley became infested much later. The mosquito became established in San Pedro del Tingo and Alangasi as late as 1917. The progress of the invasion of the region by the mosquitoes was influenced by environmental changes in the region. Earthquakes changed the courses of some of the mountain streams and also created depres-

sions in the surface of the earth which later became filled with water and served as breeding centers for the insect, and have since served as a focus for the continued infestation of the surrounding country.

The range of flight of *Anopheles pseudopunctipennis* has been observed to be between three and six kilometers, depending upon the topography and other conditions. Important among the latter are the direction and velocity of the prevailing winds. Apparently the mosquitoes are carried upward by air currents and then glide forward and downward, Thus gaining elevation as well as distance and it is thus that they have reached the highest points where they have been observed. Colder air currents and strong adverse wind direction seem to have been the

FIG. 2.—Region on the San Pedro River where the focus of infestation of the mosquito was later eliminated.

cause of the failure of the species to establish itself in Quito at 2898 meters elevation. Flight was traced by marking individuals with methylene blue mixed with talc and also by the use of eosin and neutral red. Captures were made in houses at determined distances and the mosquitoes examined to determine whether any of the marked and released females were included. In some tests releases were made at three different places and the three different marking materials were used, one from each release station. Collectors sought the mosquitoes only in houses as they seem to seek shelter and prefer the warmer conditions found in the houses. They are also strongly negatively phototropic and so must be sought in the dark spaces above the rafters of the native houses and in similar places elsewhere. The presence of man in the houses may also be an attracting factor for the mosquitoes. The phototropism was made the subject of special tests and the mosquitoes were found always to seek the darkest places provided.

By means of the capture marked mosquitoes an accurate measure of the flight range of the species was secured. The collections also served very accurately as in-

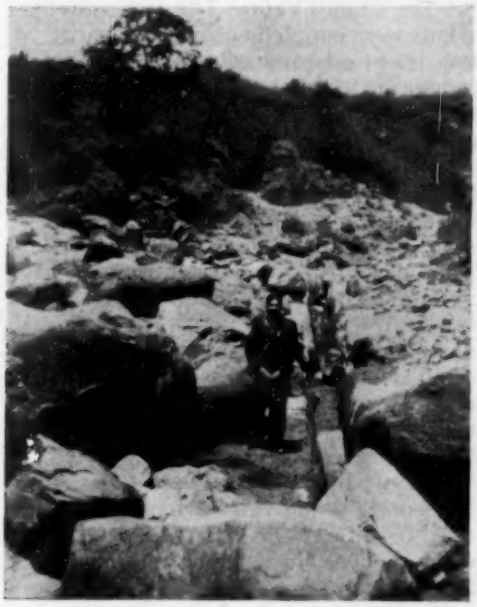


FIG. 3.—A permanent drainage ditch cut through rock draining a ravine near the town of Tumbaco.

dicators of the location of breeding places. The discovery of males in any collection indicated that the breeding places were not far away and greatly facilitated their discovery. The flight range of the males of this species was determined to be not to exceed 400 or 500 meters. The difference in the distances flown by the two sexes is explained by the fact that males, not being bloodsuckers, are not forced to make long flights in search of this food. In these studies the males were especially useful in making species determinations which are much more apparent in the males than in the females.

During the wet season the females seek shelter in dense foliage growths and, particularly, in the caves which abound in this region, many of them being made by the natives to protect themselves from show-

ers during their rainy-season journeys. When breeding conditions recur the females are no longer found in these shelters. Entomologically speaking, the wet season is that period during which breeding places are not available for the mosquitoes.

CONTROL METHODS.—Draining pools and filling depressions where water tended to collect were the main methods used during the campaign of extermination in the Los Chillos Valley. The drainage operations were supplemented temporarily by the use of oils and other insecticides for temporary control until more permanent treatment became possible. An effective system of inspection with well trained inspectors was inaugurated and the inspectors were accompanied or followed by laborers for the drainage operations. A main field laboratory was established in San Pedro del Tingo; others were located at Tumbaco, Guallabamba and Alangasi. Carefully prepared maps showing all pertinent features of the topography were divided off into squares which served as accurate means of checking the area covered as the work progressed. The inspectors indicated, in the course of their inspections, pools which were to be filled immediately and those which were to be oiled because it was not possible to fill or drain them at once. The laborers following the inspectors kept pace with the work.

Pools were oiled with crude oil mixed with crank-case oil and kerosene; this was relatively cheap as compared with the Paris-green sometimes used for *Anopheles* as the Paris-green, being an imported product, is expensive. The oil had the additional advantage of killing mosquitoes of other genera as well as the anophelines. Because of the almost universal slope of the ground in this region drainage is simple and effective. Short cuts to drain pools along streams into the main stream were readily made and the hillside pockets could usually be provided with an outlet readily. Drainage ditches were almost entirely unnecessary. Many of the drains were cut through rock, that being considered cheaper than the construction of drains from cement.

To insure thoroughness of the operations the inspectors were required to submit weekly reports showing the details of all their operations. Progress was recorded on the maps at the headquarters. By effective planning of the work it was possible to determine progress in advance and thus to make a very accurate estimate of costs. The systematic organization of the work was largely done by Dr. Jaime Rivadeneira, the Chief of the Campaign and, due to the organization which he perfected this campaign became the second one in America ever to accomplish the complete eradication of a malaria vector in an entire region. The other instance, when *Anopheles gambiae* was eradicated in Brazil, was under greatly different conditions and was accomplished at a cost vastly exceeding that of the Los Chillos campaign, even though the conditions involved in the latter were, in many ways, much more difficult.

Financing of the extermination campaign was made possible through the Inter-American Cooperative Service although the costs will be borne, ultimately by the region affected through a special tax to be collected over a period of years.

The malaria extermination campaign of the Los Chillos Valley must be considered an outstanding accomplishment. Credit for this is due Dr. Rivadeneira through whose executive and planning ability the factors of success were established. Method, work, discipline and sacrifice, were all prime factors. The results have been noteworthy. A region long unsuitable for habitation took on new life and property values rose rapidly. This was especially true after a standing offer of sixty Ecuadorian cents to be paid to any person who would deliver a mosquito to any of the field laboratories. This offer was later raised but no claimants appeared. However, no chances are being taken; a permanent inspection system is being maintained in the potentially infested area to keep down the chances of the reestablishment of the mosquito in the area.

Campaigns to eradicate *Anopheles pseudopunctipennis* are now being waged in Ibarra, Tumbabiro and Salinas, in the northern province of Imbabura, and similar campaigns are planned for the other highland provinces with the hope that in some not distant day the highland country of Ecuador will be forever free of *Anopheles* and malaria.

SCIENTIFIC NOTES

Sabadilla Dust to Control the Squash Bug[1]

R. J. Dicke, F. J. Dexheimer[2] and T. C. Allen
University of Wisconsin, Madison

Sabadilla dusts were applied as a preliminary trial to adult squash bugs, *Anasa tristis* DeG. heavily infesting squash plants in the field. Infested plants were dusted with a hand bellows duster and then covered with a screen to prevent the escape of the insects. Within a period of 72 hours the cages were removed and the dead and alive insects were recorded. Results indicated that a 10 per cent sabadilla dust was effective in reducing a high percentage of adults and nymphs and consequently replicated tests were made with laboratory equipment to determine the relative efficiency of sabadilla and pyrethrum in controlling this insect.

Table 1.—A comparative test of sabadilla and pyrethrum dusts against the adult squash bug, *Anasa tristis* DeG.

Treatment		Per Cent Toxic Constituent	Per Cent Kill[1]
Sabadilla	Diluent	Alkaloids	72 hours
30%	70%	0.80	96.0
25	75	0.67	90.2
20	80	0.54	73.3
15	85	0.40	60.0
10	90	0.27	45.6
5	95	0.13	20.4
Check			1.1
Pyrethrum	Diluent	Pyrethrins	72 hours
75.0%	25.0%	0.375	20.8
62.5	37.5	0.312	16.8
50.0	50.0	0.250	16.0
37.5	62.5	0.187	15.2
25.0	75.0	0.125	12.5
12.5	87.5	0.062	4.8
Check			0.9

[1] Based on five-replicate tests of 25 squash bugs for each level of toxicant or total of 125 bugs tested for each treatment.

Adult insects were collected in the field and placed in wire cages and subjected to known suspensions of dusts. The caged insects were exposed two minutes to the test insecticide and then transferred to clean cages and supplied with small portions of squash. Counts of dead and alive insects were made at 24-, 48-, and 72-hour intervals.

The sabadilla and pyrethrum dusts were prepared at various levels of toxic constituents. Both insecticides were diluted in the mixing of the dust with *Pyrax*. From these results, it is indicated that sabadilla (Table 1) is effective in controlling the squash bug at the higher percentages of toxic constituents.

The pyrethrum flowers employed in the dusts contained a low content of pyrethrins which accounts for the large quantity of the flowers used.—12-14-44.

[1] Approved by the Director of the Wisconsin Agricultural Experiment Station.
[2] Formerly research assistant now in the Armed Forces.

Reduction of Certain Insects Infesting Alfalfa by Use of Sabadilla[1]

T. C. Allen, F. J. Dexheimer, and Elsie Cole
University of Wisconsin, Madison[2]

During the past two years preliminary tests were made of sabadilla dusts and sprays against certain vegetable insect pests. Laboratory trials of the powdered seed (Allen & Brunn 1945) and its principal alkaloids (Ikawa *et al.* 1945) have indicated that sabadilla is highly toxic in kerosene to houseflies and in dusts to the milkweed bug (Allen *et al.* 1944). It may therefore be assumed that application of this insecticide to crops for the control of economic pests might prove effective. Preliminary trials of unpublished results by R. J. Dicke[3] of the toxicity of sabadilla dusts to vegetable insects showed that sabadilla possessed some value in controlling such pests. Further evidence of the possible utilization of this plant material in controlling certain insects when applied to crops is reported.

Sabadilla as employed in these initial trials was applied principally as dusts. The seeds of *Schoenocaulon officinale* obtained from Venezuela were milled with 50 parts of high calcic lime as previously described (Allen & Brunn 1945). Because of the oily content of the seed and the tough seed coat the procedure of milling the seed with an inert was desirable in producing a more finely powdered seed. The concentrate was then used for further dilution with a dust carrier.

In general, a finished dust containing 5 to 20 per cent sabadilla gave an expression of toxicity to those insects under consideration.

A field of alfalfa in which damage from alfalfa yellows disease and blasting of flowers had previously been known to occur was chosen for testing the dusts. Treatments were made to a plot consisting of 4-replicate blocks 1 rod square each. The plot was selected for uniformity of soil and stand of alfalfa. Dust applications were made with a hand rotary duster at the rate of 30 to 35 pounds per acre to the first and second crops. Following each application sweeps with an insect net were made at 12-hour, 36-hour, 3-day, and 5-day intervals and the insect populations determined.

In order to obtain some measurable data regarding the effect of insect reduction on possible yields and seed production, representative samplings of alfalfa were taken, weighed, and blossom abundance recorded. This procedure was practiced for the first two cuttings. The growth of alfalfa which developed after the second cutting was untreated and left for observation.

An additional plot containing 3 square rod plots was selected for treating with sabadilla and pyrethrum dusts. This plot was not replicated and served for further information as to the relative efficiency of the insecticide in reducing the insects infesting the crop.

Two dusts containing the powdered seed were employed. One dust contained 20 per cent seed, 20 per cent lime and 60 per cent Pyrax. The other dust contained 10 per cent sabadilla, 10 per cent lime and 80 per cent sulfur. The pyrethrum dust employed

[1] Approved by the Director of the Wisconsin Agricultural Experiment Station.
[2] E. H. Fisher and John Tollefson assisted in securing data.
[3] Formerly research assistant, Univ. of Wis.

contained 0.15 per cent pyrethrins and was diluted with talc and sulfur.

RESULTS.—The efficiency of sabadilla in controlling the insects infesting alfalfa under field conditions was based on the relative percentage reduction occurring in the treated and untreated plots. The average percentage reduction of leafhoppers tarnished plant bugs, and grasshoppers in the sabadilla treated plots over the checks is shown in table 1.

Table 1.—Effectiveness of sabadilla dust in reducing potato leafhoppers, tarnished plant bugs and grasshoppers inhabiting alfalfa. Madison, Wisconsin, July 11, August 17, 1944.

Dust Treatment[1]	Average Percentage Reduction Following 4 Replicated Treatments[2]			
	12 hrs.	36 hrs.	72 hrs.	5 days
	Leafhoppers			
Sabadilla	90.61	61.4	16.9	0
	Tarnished Plant Bugs			
	97.62	95.65	80.90	0
	Grasshoppers			
	97.62	98.29	92.32	75.67

[1] 20% sabadilla, 20% lime, 60% Pyrax.
[2] Total insects collected in 10 sweeps in each of 4 replicated plots following 4 applications or 160 sweeps.

Reduction in population of the 3 species of insects recorded appeared most significant at the 12-hour and the 36-hour periods. In all instances the population of insects built up rapidly 5 days following the application. This may be explained in part by migration from adjacent alfalfa fields which were heavily infested by the various insects, as well as possible deterioration of sabadilla over a 5-day period.

The relative effectiveness of sabadilla and pyrethrum dusts in reducing the potato leafhopper, tarnished plant bug, and the red-legged grasshopper is shown in table 2. Pyrethrum and sabadilla were both highly toxic to the leafhopper. Against the tarnished plant bug and the grasshopper, however, sabadilla appeared most effective. From the results of these trials, it is again evidenced that the reduction of insects caused by the insecticides was not so great after the first 36 hours after treatment.

Table 2.—Relative effectiveness of sabadilla and pyrethrum dusts in reducing potato leafhoppers, tarnished plant bugs, and grasshoppers inhabiting alfalfa. Madison, Wisconsin, July 11, August 17, 1944.

Dust Treatment[1]	Average Percentage Reduction Following 4 Treatments[2]		
	12 hrs.	36 hrs.	72 hrs.
	Leafhoppers		
Sabadilla	95.5	72.6	74.7
Pyrethrum	89.4	69.3	67.0
	Tarnished Plant Bugs		
Sabadilla	93.7	92.3	69.3
Pyrethrum	50.0	15.3	38.4
	Grasshoppers		
Sabadilla	97.7	91.9	70.0
Pyrethrum	33.8	18.1	22.5

[1] The sabadilla dust contained 10% sabadilla, 10% lime, 80% sulfur. The pyrethrum dust contained 0.15 pyrethrins I and II, 20% talc, and sulphur.
[2] Represents insects collected from 20 sweeps after each treatment or a total of 80 sweeps.

The average green weight and number of blossoms occurring in the first and second growth of alfalfa are shown in table 3. It was apparent when observing the treated and untreated plots that applications of sabadilla dusts produced a much greater yield of alfalfa, and considerably more blossoms. Seed set occurred in the first and second crops of alfalfa which were treated with the sabadilla dusts. From the data presented, the greatest benefit of dusting occurred in the second growth of alfalfa. Observations revealed that inflorescences on the sabadilla plots were much larger and the plants showed less shortening of the stems. The roots were also greater in number and more adventitious buds were present.

Table 3.—Average green weight and number of blossoms occurring in first and second growth of alfalfa treated with sabadilla dusts. Madison, Wisconsin, June 23 and August 30, 1944.[1]

Dust Treatment	Average Growth Weight from Cuttings[2] in Grams		Average No. Blossoms from Cuttings[3]	
	First Cutting	Second Cutting	First Cutting	Second Cutting
Sabadilla[4]	835.0	321.2	417.0	326.0
Check	753.0	147.3	59.0	15.0

[1] First growth alfalfa received 2 applications of sabadilla dust at 30–35 pounds per acre. Second growth received 4 applications of dust.
[2] Weight of 25 stems chosen at random from each of 4 replicated plots, or total of 100 plants.
[3] Number of blossoms occurring on 25 plants of 4 replicates each, or a total of 100 plants.
[4] The dust contained 20% sabadilla, 20% lime, and 60% *Pyrax*.

Although the data included is of preliminary nature, and results represent trials of one season, because of the need of substitute materials for insecticides made scarce due to the war, this information is made available to other workers who may wish to investigate the possible insecticidal value of sabadilla.—12-14-44.

LITERATURE CITED

Allen, T. C., and L. K. Brunn. 1945. Increased toxicity of lime-treated sabadilla seed in dust suspensions to the milkweed bug and grasshoppers. JOUR. ECON. ENT. 38(3):

Allen, T. C., R. J. Dicke, and H. H. Harris. 1944. Sabadilla, *Schoenocaulon* spp., with reference to its toxicity to houseflies. JOUR. ECON. ENT. 37(3): 400–408.

Ikawa, Miyoshi, R. J. Dicke, T. C. Allen, and Karl Paul Link. 1945. The principal alkaloids of sabadilla seed, *Schoenocaulon* sp. and their toxicity in kerosene to *Musca domestica* (Linn). JOUR. ECON. ENT. 38(3):

Toxicity of Sabadilla to Chinch Bugs and Squash Bugs[1]

H. DOUGLAS TATE and DORIS B. GATES
Nebraska Agricultural Experiment Station, Lincoln

The following report gives the results of tests to determine the toxicity of sabadilla dusts and sprays to chinch bugs, *Blissus leucopterus* (Say), and squash bugs, *Anasa tristis* DeGeer. According to the manufacturer's label, the sabadilla[2] used contained 20 per cent ground sabadilla seed, 60 per cent talc and 20 per cent lime. Lower dust concentrations were obtained by diluting this material with pyrophyllite (*Pyrax ABB*).

Toxicity was determined in two ways; by treating large masses of bugs congregated on plants and then observing the effect and by collecting bugs in the field and applying treatments under controlled laboratory conditions.

The immediate effect of the dust on both the chinch bugs and squash bugs was hyperexcitation. This was followed by decreased activity and within about 2 hours a majority of the bugs showed only feeble motion which in some individuals continued for as long as 5 days.

CHINCH BUGS.—Field tests were conducted at the time first generation bugs, which were predominantly nymphal forms, were migrating from small grain to corn. Small, triplicate areas (about 4 by 8 feet) of grass heavily infested with chinch bugs were surrounded by dust barriers of dinitro-ortho-cresol and then the area treated with a 10-per cent sabadilla dust. The barrier was maintained and the bugs kept under observation for a five-day period. Although there was some slight migration back and forth across the barrier, apparently this did not significantly influence results. Practically 100 per cent kill was obtained. As an additional check on final mortality, approximately 1000 bugs were collected from the treated areas about three hours after applying the dust and kept under observation for a four-day period. No recoveries occurred

In August and September, samples of second generation bugs were treated under controlled laboratory conditions with sabadilla dusts at concentrations of 1, 3, 5 and 10 per cent, and with sprays at concentrations of 0.5, 1 and 2 pounds of sabadilla powder per 100 gallons of water. In early July the test insects were predominantly first, second and third instars, but when the last tests were conducted on September 25 practically all were adults. Although there was some variation in susceptibility among the instars and between immature and adult forms, the differences did not appear to be marked.

Data in table 1 show that either a 5-per cent sabadilla dust or a spray containing 2 pounds of sabadilla powder per 100 gallons gave practically complete kills. In all tests an effort was made to obtain complete coverage of the bugs. Less thorough treatments, which would be likely under average field conditions, might result in somewhat lower mortality.

SQUASH BUGS.—Results of controlled laboratory tests with squash bugs are given in table 2. Either a 10-per cent dust or a spray containing 4 pounds of sabadilla powder per 100 gallons gave a high per cent kill. Lower concentrations were effective against early instar nymphs but not late instars and adults.

Field tests, which were conducted on a limited scale on hubbard and acorn squash plantings, were less conclusive than laboratory tests. It was difficult to obtain good coverage, especially in the presence of heavy vine growth, because of the tendency of the bugs to seek cover quickly when disturbed. However, results indicated that satisfactory control could be obtained by thorough application of sabadilla sprays and dusts.

Table 1.—Toxicity of sabadilla to chinch bugs.

Concentration of Sabadilla Powder (Per Cent)	Tests	Total Chinch Bugs	Mortality After 2 Days Per Cent
	Dust		
10	9	7873	98.7
5	9	6328	98.0
3	8	4691	80.0
1	8	4212	25.7
Check	7	4440	2.1
	Spray		
2 lb./100 gal.	9	1346	99.4
1 lb./100 gal.	10	3187	65.4
0.5 lb./100 gal.	6	1191	45.6
Check	12	1383	3.9

CONCLUSION.—These tests indicate that sabadilla may have a practical use in controlling chinch bugs under certain conditions: For example, in protecting especially valuable experimental material or seed crops; also in destroying chinch bugs which have collected in large numbers on the outer rows of a field of corn at the time of migration from small grain.

Table 2.—Toxicity of sabadilla to squash bugs.

	Number and Per Cent Kill[1]						
	Instars 1, 2, 3		Instars 4, 5		Adults		Total Kill
Conc. (Per Cent)	No.	Per Cent	No.	Per Cent	No.	Per Cent	Per Cent
			Dust				
10	508	99	48	87	43	83	96
5	85	99	22	45	11	45	85
			Spray				
4 lbs.-100 gal.	857	100	430	99	159	95	99
2 lbs.-100 gal.	456	100	332	79	73	84	90

[1] Average mortality in checks less than 2 per cent.

The high percentage kill of squash bugs obtained under laboratory conditions together with limited field tests indicate that sabadilla is a promising material for squash bug control.

When applying dusts some individuals experienced noticeable irritation of the respiratory passages and a tendency to sneeze. There was no evidence of phytotoxicity by sabadilla either as a water suspension or as a dust.—1-23-45.

---

[1] Published with the approval of the Director as Paper No. 370 Journal Series, Nebraska Agricultural Experiment Station.

[2] Sabadilla obtained from McConnon and Company, Winona Minnesota.

Effectiveness of Sabadilla in Control of Cabbage Worms[1]

L. K. BRUNN and T. C. ALLEN,[2]
University of Wisconsin, Madison

In 1943, preliminary field trials of various sabadilla dusts with hand operated equipment indicated that they were toxic to the imported cabbage worm, *Pieris rapae* (L.), and the cabbage looper, *Autographa brassicae* (Riley). During the 1944 season, spray and dust applications were made to cabbage with power equipment to obtain further information as to the effectiveness of sabadilla in controlling these insects. Applications of the insecticide materials were made when both the common cabbage worm and the cabbage looper were most abundant. Counts of alive insects inhabiting the cabbage plants following treatement were recorded to determine reduction of insects. The percentage insect reduction was based upon average population per head of cabbage resulting from three replicated applications. Yields were determined by recording average weight of heads cut from 80 plants in each treatment.

Table 1.—Average population of imported cabbage worms and cabbage loopers per plant and yields of cabbage following treatments with various insecticides.

Treatment	No. Imported Cabbage Worms[1]		No. Cabbage Loopers		Avg. Weight per Head[2]
	24 hrs.	24 hrs.	24 hrs.	72 hrs.	
Dust					
1	.38	.46	1.27	.44	3.75
2	1.08	5.03	.72	2.08	3.21
3	.23	1.03	.22	.45	3.49
4	.45	1.78	.77	1.35	3.49
Spray					
1	.10	.17	.71	.46	3.20
2	.40	.39	1.41	.77	3.89
3	.67	.94	1.11	1.13	3.42
4	1.13	1.47	2.55	1.62	3.08
Check	5.22	5.41	4.65	3.37	2.80

Dust 1, .5% rotenone; Dust 2, 20% calcium arsenate; Dust 3, 20% sabadilla; Dust 4, 10% sabadilla.
Spray 1, 4 lbs. cube/100 gal.; Spray 2, 4 lbs. lead arsenate/100 gal.; Spray 3, 8 lbs. sabadilla/100 gal.; Spray 4, 4 lbs. sabadilla/100 gal.

[1] Average population per head following 3 replicated applications.

[2] Average weight of heads cut from 80 plants in each treatment.

Three different materials were applied in spray and in dust forms. In this manner rotenone and arsenical materials were compared with similar preparations of powdered sabadilla seed (Table 1).

As revealed in table 1, sabadilla compared quite favorably with rotenone in reducing the cabbage worms and loopers when used in both dusts and sprays. The arsenical dust treatment appeared inferior to both rotenone and sabadilla while the spray was superior. It is possible that this insecticide may serve as a rotenone or pyrethrum substitute in controlling cabbage worms and loopers.—12-15-44.

[1] Approved by the Director of the Wisconsin Agricultural Experiment Station.

[2] John Alsterlund and Fred J. Kessler assisted in securing data.

Control of Potato Leafhoppers Infesting String Beans[1]

E. H. FISHER and T. C. ALLEN[2]
University of Wisconsin, Madison

A field of Sensation wax string beans was treated with dusts to determine the relative effectiveness of several insecticidal materials in controlling the potato leafhopper. The field was heavily infested with both nymphs and adult *Empoasca fabae*. A division of the field was made into quarter-acre plots for testing purposes. The plots were 6 rows wide and 530 feet long. Treatments were applied with a large power Niagara duster at the rate of approximately 35 pounds per acre.

Records of nymphal and adult leafhopper populations were made 12 hours before application and 24 and 72 hours after application. Four replicate counts were taken from 4 different locations in each treated plot. Nymphal counts were made by counting the total insects inhabiting 10 upper and 10 lower trifoliate leaves chosen at random from plants located in four different locations in each plot, or the insect populations inhabiting 80 leaves. Adult counts were made by taking 10 sweeps at 4 different locations in each treatment.

Table 1.—Relative effectiveness of various insecticidal dusts in controlling the potato leafhopper nymphs and adults inhabiting string beans. Cumberland, Wisconsin, June 30 to July 5, 1944.

Dust Treatments	Average Percentage Reduction of Leafhoppers	
	24 hrs.[1]	72 hrs.[2]
Adults		
I Sabadilla	97.8	93.8
II Dinitro-o-cyclohexylphenol	92.1	85.0
III Sabadilla	88.9	87.5
IV *Lethane B71*	76.1	62.5
V Pyrethrum	88.6	75.0
Nymphs		
I Sabadilla	96.4	97.6
II Dinitro-o-cyclohexylphenol	94.5	96.6
III Sabadilla	95.0	87.8
IV *Lethane B71*	81.3	64.8
V Pyrethrum	92.0	79.3

[1] Based on 12-hour count before treatment.

[2] Based on 72-hour count of check.

The dusting materials employed were as follows:

Sabadilla 10 per cent, lime 10 per cent, sulfur 80 per cent.
Dinitro-o-cyclohexylphenol 1 per cent (*DN-5*).
Sabadilla 10 per cent, lime 10 per cent, Georgia talc 80 per cent.
Pyrethrins 0.02 per cent, synergist, 0.5 per cent.
Aliphatic thiocyanate 14 per cent (*B-71*).
Check.

RESULTS.—The average percentage reduction of nymphal and adult leafhoppers is shown in tables

[1] Approved by the Director of the Wisconsin Agricultural Experiment Station.

[2] James McConnon and R. A. Biron assisted in securing data. E. H. Fisher now entomologist for Stokely Foods, Inc.

1A and 1B. Statistical analyses of these data show that a significant difference occurs between treatments at the 5 per cent and 1 per cent levels.

It is apparent that sabadilla dusts are effective in reducing adult and nymphal leafhopper populations over a 72-hour period. The addition of sulfur to sabadilla apparently aided in its extended toxicity throughout the 72-hour period.

Due to the favorable results obtained from these trials, sabadilla has already served to meet an emergency in the vegetable canning industry of Wisconsin. In 1944, a large quantity of dust was applied to string beans for the control of the potato leafhopper. A total of approximately one million pounds of sabadilla dusts was employed for controlling such insects as leafhoppers on vegetable crops, cranberry insects, and pests of livestock during the past season.—12-14-44.

A Microsporidian in *Macrocentrus ancylivorus*

H. W. ALLEN and M. H. BRUNSON, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During a study of the propagation of *Macrocentrus ancylivorus* Rohwer on the potato tuber worm *Gnorimoschema operculella* (Zell.), in the summer of 1944, a considerable number of the adult parasites were found to differ from normal specimens in having conspicuous whitish areas in the abdomen, best seen from the ventral aspect.

When adults with whitish abdomens were dissected, it was found that this coloration was due to more or less globular bodies visible to the naked eye. These bodies were found to be teeming with oval microorganisms. These organisms have the contours of an ordinary gelatin capsule. They range from 3.7 to 5.0 microns in length and from 1.8 to 2.2 microns in width. In a water mount they are refractive and show little or no internal differentiation. They are resistant to weak stains, but stain slowly when a drop of 10 per cent aqueous Kinyoun carbol-fuchsin is allowed to seep in from the side of a cover glass over a water mount. Within a few minutes a considerable portion of the spores, after absorbing the stain, extrude a long polar filament, which is usually wavy or spiraled for a portion of its length. This polar filament averages 82 microns in length. The organism appears to be a microsporidian. An identification will be obtained in the near future, if possible.

Many *Macrocentrus ancylivorus* adults infected with this microsporidian have swollen and malformed abdomens, and some in this condition are scarcely able to fly. Diseased adults have a shorter life span than healthy ones. In preliminary tests it was found that diseased females live about three-fourths as long as healthy ones, and diseased males only half as long. The incidence of diseased adults in 117 progeny of diseased parents was 39 per cent, and in 333 progeny of healthy parents 40 per cent. This observation indicates that prevalence of disease is probably not correlated with the presence of disease in the parasites used in breeding. Diseased parasites reproduce, but the total number of parasites obtained from 29 diseased females was 182, or only slightly more than a third of the 498 obtained from a check lot of 29 healthy females. The ratio of females to males was as high in the progeny of diseased females as in the progeny of healthy ones — 2-19-45.

Quieting Mosquito Larvae[1]

JOHN B. GERBERICH, *Ohio State University, Columbus*

To observe detailed structures on living mosquito larvae without inhibiting the development it is necessary to quiet them. Low temperatures have been used with limited success. Recently the author has used *Methocel*[2] and wishes to report upon some interesting results. *Methocel* was suggested to the article by D. A. Marsland in Science, November 5, 1943 in which it was reported that *Methocel* has a quieting effect on Paramoecium.[3]

The efficiency of methyl-cellulose depends upon its high viscosity, low tonicity and non-toxic properties. As the solvent evaporates the viscosity increases and the movements of the insect become less. The proportion of *Methocel* for quieting paramoecium was employed on the mosquito larvae namely a 10 per cent solution of methyl-cellulose (Dow Chemical Company; Viscosity type, XX low).

The first step in the method is to place one drop of *Methocel* from a medicine dropper pipette in the pit of a depressed slide. Using a clean pipette transfer a mosquito larva from the culture to the slide being careful not to add more than one drop of water with the specimen. The larvae should be placed directly on top of the *Methocel*. Mix the drop of water with the *Methocel* by means of a dissecting needle. The mixture should fill the depression and the specimen will be flat and surrounded by the mixed fluid. The slide may then be left for ten to twenty minutes depending upon the rate of evaporation. If the specimen is still too active another drop of *Methocel* may be added and mixed with the fluid already upon the slide. If care is used one may increase the concentration of the *Methocel* by applying a small amount of heat. When the right degree of viscosity is reached the mosquito larva will become quiescent. If one applies light, as in the case of a substage lamp or any other type of microscope illumination, the specimen will react to the stimulus for a short period of time but becomes quiet very quickly. The specimen can be left in *Methocel* for an indefinite period as long as the methyl-cellulose is in a gel state. When most of the water has evaporated from the methyl-cellulose it becomes hard and may serve as a temporary mount. If living specimens are to be kept in *Methocel* for long periods of time, a small drop of water can be added repeatedly to the mixture to maintain the gel state.

The question arose as to what effect *Methocel* would have upon the development of the larvae. A few living specimens have been kept in *Methocel* for 24 hours in high humidity without apparent injury. In order to test the influence that *Methocel* might have on the development of larvae, living specimens were placed in the quieting solution for 3 hours each day during their entire period of development. If *Methocel* has any detrimental effect upon the developmental longevity of the larvae, it should become obvious in the following test.

Aedes aegypti[4] eggs were secured from a dry ovipositing block. Upon immersion in water the eggs hatched in 17 minutes, plus or minus. One-hundred of these young larvae were individually isolated into

[1] Contribution of the Department of Zoology and Entomology.
[2] *Methocel*, a product manufactured by the Dow Chemical Company, Midland, Michigan.
[3] The author has used methocel on other Protozoa successfully such as Euglena, Vorticella etc.
[4] *Anopheles quadrimaculatus* Say, was given the same treatment with *Methocel* and this proved successful.

separate dishes. The specimens were divided into two groups. The first 50 were treated with *Methocel* and the second 50 served as the control group. Each specimen of the *Methocel* group was handled each day according to the foregoing method described for the quieting of the mosquito larvae. Daily each larva was kept in the *Methocel* mixture for three hours then returned to its respective dish. Each specimen of the control group was handled under the same conditions except water replaced *Methocel* on the slides. The results of the effect of *Methocel* upon the developing period of the larvae is recorded in table 1.

Table 1.—Rate of pupation under the influence of *Methocel*. (Fifty specimens per group)

Age in days	Control Group		Methocel Group	
	Pupae	Larvae	Pupae	Larvae
7	0	50	0	50
8	3	47	0	50
9	25	25	20[1]	30
10	45	5	40	10
11	49	1	48	2
12	50	0	49	1[2]

[1] Three of this group pupated in the *Methocel* solution when on the slide.
[2] This larva did not develop. At the end of the experiment it was alive, active and still in the second instar.

SUMMARY.—All larvae survived the treatment which seems to justify the conclusion that *Methocel* has no toxic effect upon the mosquito larvae. Practically all the larvae in the check and test groups pupated within 12 days after hatching and all pupae produced normal adults. Since the material appears to be non-toxic and has no effect upon the rate of development, it is recommended as a satisfactory substance for quieting mosquito larvae. It may also prove satisfactory for quieting other aquatic larvae. —12-26-44.

Mass Production of *Trichogramma* Using Eggs of Potato Tuber Worm

STANLEY F. FLANDERS, *University of California, Citrus Experiment Station, Riverside*

The successful utilization of the potato tuber worm, *Gnorimoschema operculella* (Zell.), as a host of *Macrocentrus ancylivorus* Rohr. (Finney *et al.*, 1944) has stimulated renewed interest in the mass propagation of beneficial insects. Economic control of a pest by mass liberations of a parasite depends primarily on the low costs of production and liberation. If such costs are sufficiently low control may be effected through the *inundation* of an area by the individuals liberated rather than by the *accretion* of their progeny. In future work the inundation method will receive more emphasis than in the past, since it offers greater hope for success than the accretion method (Flanders 1930 B).

The tuber worm will be subjected in due course to parasitization by the parasites of various injurious *Lepidoptera*, especially those which deposit their eggs unprotected on the surface of plants or whose larvae have the habit of working on succulent plant tissues either internally or externally within a protective webbing.

Fifteen years ago the writer reported (Flanders 1930 A) that the females of *Trichogramma* reared from the eggs of the tuber worm were larger, that is, greater in girth than those reared from the eggs of *Sitotroga*. Although the tuber worm egg contains more nutrient than the *Sitotroga* egg it is not as a rule sufficient for the development of more than one *Trichogramma* female. Consequently it is usable for mass production work. It is extremely doubtful if larger eggs can be so used.

The robust character of *Trichogramma* from tuber worm eggs and the recent discovery that this host can be reared in enormous numbers and can be forced to fasten its eggs uniformly over a sheet of cloth or paper have increased the chance of the successful utilization of *Trichogramma* only if used in the inundation of areas infested by its hosts. Enough females of *Trichogramma* should be released at a time to search every square centimeter of the surface of all plants within the distributional area of the parasite.

In obtaining an even distribution of host eggs on the cloth or paper the tuber worm adults are confined in a flat, 18-inch mesh wire screen cage. Newly emerged anesthetized adults are measured and then poured into the cage each day at the rate of about 10 adults to each square inch of the top surface of the cage. In one corner of the cage is an aperture for pouring in the anesthetized adults and for discarding the dead ones. The latter may be removed with an aspirator every 4 or 5 days. Each day a sheet of cloth or paper is thoroughly wetted and then placed on top of the egg deposition cage. When in position it is smoothed out so that it makes contact at every point. The top side of the cage should not sag in the slightest degree. The adults deposit their eggs through the wire and onto the sheet. During egg deposition the cage is kept on a rack in total darkness. In order to prevent the deposition of eggs on any part of the cage it should previously have been dipped in hot paraffin in a manner described by Marvin (1944).

The egg sheets are removed daily and placed for parasitization in open wooden boxes or cells stacked in front of a large window. The end of each cell facing the window is closed with glass, the other end is kept open and unlighted. Each cell contains a thin, rigid, plate 15 inches square mounted on 4 short pegs so that it can be removed and replaced with little injury to parasites on the floor of the cell. The heads of several brads placed on the edges of the plate allow the parasites to move freely about the cell when the plate is in position against the glass end. There should be only enough clearance between the plate and top of this cell for the egg sheets when they are laid out on the plate. The plate is handled most readily if, when in position, it extends out of the open end of the cell by about an inch.

The egg sheets are cut to equal one third of the plate so that when the parasitization unit is in operation the plate bears (1) a sheet of fresh eggs (2) a sheet of eggs parasitized during the preceding 24 hours and (3) in the area between these sheets portions of egg sheets from which enough parasites are emerging to parasitize the fresh eggs.

Each day the sheet of eggs parasitized 2 days previously is removed from the plate and replaced with new sheet of eggs. The plate is then reversed in position so that the fresh egg sheet is adjacent to

the window, where it receives the parasites from the other sheets.

The parasites can be fed undiluted honey if the moisture content of the room is maintained at about 60% relative humidity. The honey should be placed in hair line streaks on strips of waxed paper.—8-26-45.

LITERATURE CITED

Finney, Glenn L., Stanley E. Flanders and Harry S. Smith. 1944. The potato tuber moth as a host for the mass production of *Macrocentrus ancylivorus*. JOUR. ECON. ENT. **37**: 61–4.

Flanders, Stanley E. 1930A. Mass production of the egg-parasites of the genus *Trichogramma*. Hilgardia **4**: 465–501.

Flanders, Stanley E. 1930B. Evaluation of *Trichogramma* liberations. JOUR. ECON. ENT. **23**: 886–7.

Marvin. P. H. 1944. Obtaining eggs of the potato tuber worms for use in the mass breeding of *Macrocentrus ancylivorus*. JOUR. ECON. ENT. **37**: 560.

Control of Several Scales Infesting Orchids

ERNEST N. CORY, *College Park, Md.*

Certain of the scale insects represent one of the important limiting factors in orchid production. Many growers feel that they can keep the scales to such low numbers that they will not interfere with production. Most growers clean plants when they repot, but it is obvious that this practice is inadequate as many plants are rendered unproductive by scales, eyes are destroyed and some plants may be totally destroyed.

Starting in 1939, tests of various control measures were instituted on plants furnished by Siegwart and Slotter, Jessups, Maryland. Successively and sometimes concurrently, tests were conducted on individuals and groups of plants with *Loro, Black Leaf 40, Special Red Arrow,* castor oil soap and *Volck* with and without nicotine and on cymbidiums before and after spraying with Burgundy mixture for the control of a fungous leaf spot. In general no thoroughgoing control of any scale species was obtained with any of the materials mentioned. *Loro* 1–400 was successful in almost complete extermination of *Pseudoparlatoria parlatorioides* (Comst.) on cypripediums although after approximately one and one-half years, scales reappeared on three plants. The often practiced regular spraying with nicotine failed to reduce appreciably any scale and apparently was wholly ineffective against Boisduval's scale. Even *Volck* oil at 1 per cent failed to control completely any of the several scales though used regularly every 2 weeks at 1 per cent for over six months on cymbidiums, cattleyas and phalaenopsis.

In August 1944, tests were begun with DDT emulsion on limited numbers of *Cattleya Percivaliana* and *Bowringiana* and on *Epidendrum tampaesis*. As no injury developed, the list of genera and species treated was extended gradually until all the orchids in the house were sprayed regularly.

The following scales were included in the tests: *Lepidosaphes tuberculatus* (Sign.), *Chrysomphalus dictospermi* (Morg.) and *Coccus pseudohesperidum* (Ckll.) on *Cymbidium* and the latter on *Epidendrum*. *Pseudoparlatoria parlatorioides* (Comst.) and *Parlatoria proteus* Curt. on *Cypripedium*; *Diaspis boisduvali* on *Cattleya, Epidendrum* and *Oncidium*; *Saissetia hemisphaerica* (Targ.) and *Coccus hesperidum* L. on *Dendrobium, Phalaenopsis, Vanda, Oncidium, Calanthe* and *Cyrtopodium*. In some cases two or more species occurred on a single host.

The DDT emulsion followed the Federal formula of 20 parts DDT dissolved in 60 parts of xylol which was then emulsified with 20 parts of *Triton*. Twenty cubic centimeters of this solution was used in one quart of water giving 0.022 per cent of DDT in the final spray. This was applied with an electric powered atomizer until the plants were completely covered with fine droplets and some surplus was running down the stems into the crown.

Without detailing many individual tests made for specific purposes such as phytotoxicity, it is sufficient to point out that the following genera and species have been treated four times at intervals of approximately three weeks: *Cattleya Percivaliana, Schroderae, Trianaei, Mendelii, amabilis* and *Bowringiana*; *Phalaenopsis alpha, amabilis* var. Katherine Siegwart, *Schilleriana* and *Rothschildiana; Cymbidium* hybrids; *Calanthe; Cypripedium* hybrids; *Oncidium altissimum, microchilum, splendidum* and *luridum; Miltonia* hybrids; *Vanda coerulae* and *suavis; Aerides crispum; Dendrobium nobile, phalaenopsis* and one unlabeled species; *Epidendrum tampaesis, atropurpureum* and *cochleatum* and an unlabeled species; *Coelogyne cristata, Laelia anceps; Cyrtopodium* sp. and *Brassavola Digbyana*.

After a lapse of approximately 4 months from the time of the first complete spraying the writer has been able to find only a single live scale. Removal of the sheaths about pseudo bulbs shows complete kill beneath the sheaths—all crawlers that have attempted to settle have been killed. No attempt has been made to determine the lowest lethal dilution, but it is quite possible that 0.01 per cent might be just as effective as a great deal of the kill depends upon the residual effect. Growers should test this material cautiously, as the conditions in other greenhouses might vary considerably.

The only damage that has developed is a more rapid yellowing of leaves that apparently were mature and would have finished their function and dropped shortly. Slight damage and complete control of *Saissetia hemisphaerica* (Targ.) on maidenhair fern resulted from a single spraying. Cattleya plants freed from scale have developed new roots and eyes; sometimes two eyes have developed to a single shoot and occasionally on the second node. Commercial houses sprayed with 0.4 per cent showed remarkable improvement in growth in two weeks, especially community pots with plants from six months to one and one-half years of age.—2-25-45.

A Calcium Cyanamid-Sodium Fluosilicate Mixture for Use as a Defoliant

S. MARCOVITCH, *Tennessee Agricultural Experiment Station, Knoxville*

Calcium cyanamid has been successfully used for defoliating cotton. A good cotton defoliant has so many advantages as to warrant increased attention.

In water calcium cyanamid slowly hydrolyzes to form hydrogen cyanamid and calcium hydroxide. This latter acid compound is responsible for the toxic

effects produced. It may also be formed more readily by the addition of any acid or acid salt such as dodium fluosilicate. The amount of acid in sodium fluosilicate can be better visualized through the following reaction:

$$Na_2SiF_6+4NaOH=6NaF+Si(OH)_4.$$

With cyanamid the following reaction would take place:

$$2CaCN_2+Na_2SiF_6+2H_2O = 2H_2CN_2+2CaF_2+2NaF+SiO_2.$$

Experiments were, therefore, undertaken to note the effect of a combined dust or spray of the cyanamid with Na_2SiF_6 as follows:

Calcium cyanamid	25%
Sodium fluosilicate	25%
Pyrophyllite	50%

The presence of the pyrophyllite seemed to improve the dusting qualities of the cyanamid.

The tests on single plants indicated that the above combination was equally as effective as the straight cyanamid. A spray made up as follows was also effective:

Calcium cyanamid	4 lbs.
Sodium fluosilicate	4 lbs.
Water	50 gals.

With the combination the injury appears sooner on the leaves than with the straight cyanamid.

Since sodium fluosilicate has insecticidal properties, its use would have the additional advantage of destroying the boll weevil and pink bollworm.

Five per cent sodium arsenite as well as 25 per cent sodium chlorate were also tried out. While these materials injured the leaves, they do not appear to stimulate an abscission layer of cells with the result that they do not drop off completely. Ten per cent urea was not effective.

Calcium cyanamid is also used for weed control in tobacco plant beds. It is possible that in combination with sodium fluosilicate, the readily produced hydrogen cyanamid would be more toxic. This combination might also have possibilities as a spray for thinning applies when in bloom.—1-2-45.

Gelatin Capsules Used in Studies of Insect Parasites

W. G. WELLINGTON, *Meteorological Service of Canada, Toronto, Ont.*

Among the functions of the adaptable gelatin capsule is its use as a rearing container for the more minute forms of insect parasites. It is but a short step from this use in practical rearing methods to the use of the capsules in purely experimental studies upon certain phases of the biology of cocoon parasites and internal parasites. A brief description of such uses for the capsules is contained in the following note.

Many insect larvae, living as external parasites within a host-cocoon, perish if the envelope is opened for one or more examinations of the parasites *in situ*. If there is a shortage of material, as is often the case in a preliminary study, such destruction often results in an indefinite suspension of the work. By substituting a gelatin capsule for the host-cocoon, it is possible to follow the development of the parasite without disturbing any factor of its habitat.

This technique is best illustrated by a brief description of its use by the writer during a study of the Pteromalid parasite, *Dibrachys boucheanus*, Ratz. The purpose of this work was to obtain information upon the stimuli governing oviposition, the method of oviposition upon the host through a cocoon-wall, and, finally, on the movements of feeding larvae over the host-body. For the latter study, it is obvious that continued observations upon a single parasitized host would be desirable.

In practice, an individual host was coddled, and placed within a capsule, which was then offered to ovipositing females. The resilience of the capsule-wall prevented penetration by the ovipositors of the parasites, so that it was found necessary to pierce the capsule at some point. The females oviposited readily through this artificial opening, and, since the capsule was transparent, their methods of oviposition could be observed.

Throughout the development of the immature stadia, any observations with a binocular could be made without disturbing the contents of the capsule. It was necessary, however, to liberate newly-emerged adults, since these made no attempt to enlarge the original puncture, or to cut a fresh escape-opening.

Apanteles carpatus, Say, an internal parasite of the larva of the case-making clothes moth, affords an illustration of another use for gelatin capsules. As in the previous example, the writer was concerned with the stimuli governing oviposition, and, particularly, whether an internal parasite could be induced to oviposit in unnatural media.

In these experiments, the capsule functioned as a framework for various artificial hosts. A small portion of the capsule-wall was removed, and various substances (*i.e.*—larval silk, frass, or skin) were stretched over the gap. As with *Dibrachys*, the hole was cut to aid attempted oviposition within the capsule. The capsule, with its attractant, was then offered to the parasite. Again, it was possible to observe any attempts at oviposition through the transparent capsule-wall.

As a matter of general interest, it may be stated that one *Apanteles* was induced to deposit one egg within the airspace of the gelatin capsule. This result was obtained with difficulty, but the writer feels that oviposition could be induced quite readily if some gelatinous substance was placed directly beneath the host-material found to be the final attractant. In general, it does seem necessary for the tip of the ovipositor to pierce some semi-solid medium which implies the presence of a "host."

The two examples given above indicate the use of gelatin capsules in some phases of experimental work with insect parasites. The capsules provide a means of observation upon the mechanism of oviposition by forms which normally deposit eggs beneath an opaque surface. They afford a means of studying the development of normally-concealed forms, such as cocoon parasites, without undue disturbance. Finally, they may provide a means of observing the oviposition of a normally internal parasite, and, if coupled with a gelatinous medium, may aid in obtaining the eggs of such a form for description or for transplantation experiments, thus dispensing with the dissection of the parasite or host.—1-4-44.

Infestation of a Red Fox by *Amblyomma americanum*

ROLAND W. PORTMAN,[1] and PAUL D. DALKE,[2]
Columbia, Missouri

In January 1945, a pelt of a red fox was received from Mr. E. W. Woods of the U. S. Forest Service, at Ironton, Missouri. On the visceral side of the skin the entire abdomen was covered with small dark red spots which were embedded in the connective tissue. There were over 150 of these spots and were found to be the larvae, nymphs and adults of the lone start tick, *Amblyoma americanum*. Of this number 109 were nymphs, 36 adults and the larvae made up the remainder. There were undoubtedly others but these were all that could be distinguished.

The ticks which had only a thin layer of connective tissue covering them were easily seen and distinguished but those which were deeply embedded showed only as spots. One female, partly engorged, was found hanging to some fatty tissue and was just a hard robust shell, while all the others were perfectly preserved and entirely flat. The legs and body of the ticks were interwoven with the fibrous connective tissue of the derma. There was no apparent necrotic tissue about any of the specimens. None were enclosed in nodules as was found by Bell and Chalgren (1943).

The general belief is that the long hypostome of the tick causes a local reaction in the tissue which swells, engulfing the entire tick. Further explanation of this process has been forwarded by Nuttall (1914) and Trager (1938).—2-14-45.

LITERATURE CITED

Bell, J. F., and W. S. Chalgren. 1943. Some wildlife diseases in the eastern United States. Jour. Wildlife Management. 7(3): 270–7.

Nuttall, G. H. F. 1914. Penetration of *Ixodes* beneath the Skin. Parasitology. **7**: 258–9.

Trager, W. 1938. Acquired Immunity to Ticks. Jour. Parasitology. **24**: 20.

[1] University of Missouri.
[2] Missouri Cooperative Wildlife Research Unit.

Fuel Oil as a Larvicide for the Tobacco Flea Beetle

J. U. GILMORE and CLEMENCE LEVIN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

The control of the tobacco flea beetle, *Epitrix hirtipennis* Melsh. (formerly *E. parvula* (F.)), in tobacco plant beds by sanitation and the use of tight covers for the beds has been discussed by a number of investigators, including Metcalf and Underhill (1919) and Levin (1940, 1943). More recently Gilmore and Levin (1944) have found that flea beetles developing in abandoned tobacco plant beds are a menace to fields of tobacco nearby, and that their numbers can be reduced by destroying the surplus plants either by pulling them and scraping the ground or by plowing and harrowing. All are sound measures to use in reducing present or potential flea beetle populations.

With the tight cloth-covered bed, as with other plant beds, the cover must be removed for several days prior to transplanting, to harden the plants. It is during this time that flea beetles already emerged from hibernation gain access to the bed and deposit eggs for the first brood. Recommendations for insecticide applications at this time are rarely followed. Occasionally insecticides are applied just before the plants are pulled, and this tends to lower or restrict subsequent plant-bed infestations. If these infestations are allowed to increase all summer, great numbers of flea beetles will continue to be produced therein and infest tobacco growing in fields nearby. Accordingly, after the value of the prompt destruction of surplus tobacco plants remaining in the plant beds had been determined, additional research was conducted at Oxford, N. C., to discover a method of destroying the larvae in the soil of the beds.

Table 1.—Tobacco flea beetles developing from tobacco plant beds treated with different larvicidal materials.

TREATMENT	QUANTITY PER SQUARE YARD	FLEA BEETLES PER SQUARE FOOT	REDUCTION IN FLEA BEETLES
1942	*Fluid Ounces*	*Number*	*Per Cent*
Fuel Oil	16	0.5	100
Paradichlorobenzene	8[1]	29.2	78
Gasoline	16	45.7	65
None (check)	—	131.3	—
1943			
Fuel oil	16	0.4	98
	11	1.0	94
	5	2.0	89
None (check)	—	17.7	—

[1] Ounces by weight.

Late in May 1942, soon after tobacco transplanting had been completed, three materials were selected for tests on flea beetle larvae—plain gasoline, fuel oil, and paradichlorobenzene. Three replicates of each treatment were made in a randomized-block experiment. The materials were applied to 2-square-yard plots in a plant bed after the plants had been cut off less than an inch from the ground with a weed cutter. The liquids were applied with a small sprinkling can, and the crystals were broadcast by hand. Immediately after treatment five cylindrical cloth-covered cages, described by Gilmore & Levin (1942), each covering an area of 1 square foot, were placed on each plot. These cages were then thoroughly dusted with a mixture containing 1 per cent of rotenone to kill any adult beetles present. Two days later each cage was inspected to record numbers of recently emerged beetles. These examinations were repeated three times a week for a month. As shown in table 1, the number of adult beetles developing during this period was reduced from 131 per square foot in the check plots to 0.5 in the plots to which fuel oil had been applied. The gasoline and the paradichlorobenzene were relatively ineffective.

In 1943 the investigation was continued with fuel

[1] In cooperation with the North Carolina Department of Agriculture, the North Carolina Agricultural Experiment Station, and the Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture.

oil alone, since this material appeared to be far better than either of the others. Accordingly, in June 1943 the same general procedure was followed as in 1942 but with the addition of another replicate. Sufficient water to make 1 pint was mixed with each of the last two dosages to facilitate uniform distribution of the liquids. Agitating the oil and water by means of a small force pump produced a mixture that was sufficiently stable for this purpose.

As shown in table 1, the reduction in adult flea beetles developing in the plots ranged from 89 to 98 per cent depending upon the dosage. The smallest dosage was as effective as the best cultural treatment reported by Gilmore & Levin (1944). The cost of the 1-pint dosage of fuel oil would not be over two dollars per 100 square yards of plant bed.

A possibility existed that fuel oil applied to tobacco plant beds might harm crops planted following the treatment. Accordingly, 30 days after treatment in 1943 the soil in each square-foot cage used in the experiment was loosened with a trowel, and two seeds of each of the following crops were planted: Corn, snap beans, soybeans, wheat, and cowpeas. When these cages were examined 3 weeks later, on the basis of germination and subsequent growth, corn, soybeans, and cowpeas suffered no injury from the oil treatments. Although the germination was not quite so good, the growth of snap beans and wheat appeared to compare favorably with that in the untreated plots.

These tests indicate that the cutting off of tobacco plants in an abandoned plant bed, followed by the application of fuel oil, is highly effective in reducing the number of flea beetles to emerge later. This procedure is therefore very desirable for the protection of field tobacco from flea beetles.—4-9-45.

LITERATURE CITED

Gilmore, J. U., and C. Levin. 1942. A recovery cage to determine the numbers of flea beetles emerging from soil surrounding host plants. U. S. Bur. Ent. and Plant. Quar., ET-197.

Gilmore, J. U., and C. Levin. 1944. Control of the tobacco flea beetle by cultural practices in plant beds. JOUR. ECON. ENT. 37(1): 13–15.

Levin, C. 1940. Breeding hosts of the tobacco flea beetle. JOUR. ECON. ENT. 33(3): 473–5.

Levin, C. 1943. The effect of tobacco plant-bed construction on the development of flea beetle populations. JOUR. ECON. ENT. 36(4): 622–3.

Metcalf, Z. P., and G. W. Underhill. 1919. The tobacco flea beetle. N. C. Agr. Expt. Sta. Bul. 239.

Christmas Tree Quality Improved by Methyl Bromide Fumigation

RANDALL LATTA, *U.S.D.A., Agr. Res Adm., Bureau of Entomology and Plant Quarantine*

During the past 3 years repeated fumigations with methyl bromide by C. H. Gaddis of cut fir and spruce trees intended for use as Christmas trees have been made to test the effect on their quality when such fumigations were used under provisions of the gypsy moth quarantine. All trees used were taken from stocks of commercial Christmas tree shippers in Maine and Vermont. All were forest green and had been cut and piled 15 to 40 days prior to treatment.

Trees were included in experimental fumigations in a 100-cubic foot chamber with dosages of 2.5 and 3 pounds per 1000 cubic feet and exposure periods of from 2.5 to 8 hours at prevailing temperatures (above 32°). Others were removed from car-load lots that had been fumigated with 2.5 pounds for 6 hours in routine treatments of trees being shipped from the quarantined area. In some instances the same trees were included in as many as four consecutive routine fumigations, thus being subjected to 24 hours' total exposure with the dosage renewed each 6 hours.

All fumigated trees, with appropriate checks, were placed in heated rooms having an average temperature of about 80°F., and were kept under observation for periods of from 19 to 39 days. In every instance the fumigated trees retained their needles and color longer than did the untreated trees. This condition was more noticeable in the fir than it was in the spruce trees. It was observed that trees treated with a high dosage or that had been exposed to the gas for long periods were decidedly better at the end of the holding period than were either the checks or the ones treated with lower dosage or shorter exposure. The needles were still flexible, the buds were not dried out and shrunken, and the color was almost normal.—2-19-45.

Effect of Cattle Grub Treatment on Weight Gains in Beef Cattle

HAROLD GUNDERSON, *Iowa State College, Ames*

In December, 1942, Iowa began an intensive campaign to control cattle grubs. At this time, it was found that there was little or no information available on the immediate effects of treatment with rotenone-bearing dusts and sprays. Numerous statements were found which indicated that beef cattle "did better" or "gained more" following treatment for grubs, but data on actual increases in the rate of gain were not given.

The cooperation of the Rath Packing Company and John Morrell and Company were obtained, and during the winters of 1942–1943 and 1943–1944, demonstrations were set up to determine the immediate effect of cattle grub control.

In all of these tests, cattle of approximately the same age, weight, condition and degree of grubbiness were chosen. The grub infestation at the time of the first treatment ranged from 20 warbles up to 60 or 80. Both *Hypoderma lineatum* (DeV.) and *H. bovis* Deg. were involved in the different tests.

The cattle grub spray contained 5 pounds of 5 per cent rotenone and 10 pounds of wettable sulphur in each 100 gallons of spray. The spray was applied at nozzle pressures ranging from 250 to 450 pounds. The cattle grub dust used in 1942–1943 contained 2.5 per cent rotenone with wettable sulphur; that used in 1943–1944 contained 1 per cent rotenone with pyrophyllite. From 2 to 3 treatments were applied to each test lot of cattle.

In making each test, a uniform group of feeding cattle was divided at random into two lots, one for treatment and one for a check. The cattle in each lot were conspicuously marked with paint or by electric clipper. Both lots of cattle were weighed, and

one lot was run through a treating chute where the cattle were either sprayed or dusted. Following treatment, both lots of cattle were placed together in the same feed lot where they were given the same ration. Thirty days after the first treatment, the two lots of cattle were again separated and weighed; the treated cattle were given a second application of spray or dust, and both lots were then returned to the feed lot for further feeding.

nearly 100 pounds each during 16 days of extremely unfavorable weather. In a long-time feeding test, differences in individual cattle which are not apparent to the eye at the beginning of the test may greatly influence the weight of the entire lot. However, it is felt that the results reported here are those which may be obtained by any cattle feeder following the control of cattle grubs.

SUMMARY.—The results of 6 tests with 219 head of weighed cattle which were treated with rotenone bearing dusts or sprays to control cattle grubs indicate that the treated cattle gained from 0.1 to 0.42 pounds per day more than similar weighed lots of untreated cattle. In one case, the untreated cattle gained faster during the second 30-day period than did the treated group.—4-6-45.

Table 1.

LOCATION	OTTUMWA IOWA	WATERLOO IOWA	WATERLOO IOWA	SIOUX FALLS S. D.	OTTUMWA[1] IOWA	TOPEKA[2] KAN.	TOPEKA[2] KAN.
Date of treatment	12-19-42	2-2-43	2-2-43	2-11-43	12-18-43	1-14-44	2-14-44
No. head treated	44	30	30	50	50	15	same cattle
Av. wt. at start of test	1029	approx. 1000	approx. 1000	837.4	1096	734	813.6
Av. wt. at end of test	1144			1012.5	1232.6	813.6	886.6
Treatment	Spray	Spray	Dust	Spray	Dust	Dust	Dust
No. applications	2	2	2	2	3	1	1
Gain in lbs. per steer over controls	5	9	9	21.4	12.9	12.6	10.6
Test period, days	51	45	45	80	90	30	30
Increased rate of gain per day lbs.	0.1	0.2	0.2	0.26	0.144	0.42	−0.25

[1] Dickey, E. S. Report of cattle degrubbing test. Iowa Veterinarian 15 (4): 8, 1944.
[2] Reported by Ray L. Cuff, Regional Manager, Livestock Loss Prevention Board, Kansas City, Mo.
Sioux Falls Test reported by D. W. Breese, John Morrell & Co., Sioux Falls, S. D.
Waterloo test reported by John W. Coverdale, Rath Packing Co., Waterloo, Iowa.
Ottumwa tests reported by Dr. E. S. Dickey, John Morrell & Co., Ottumwa, Iowa.

In one case, a third grub treatment was applied 30 days after the second treatment, but in most tests the cattle were slaughtered 10 to 20 days after the second treatment.

The results of these various tests, shown on table 1, indicate that there is considerable variability in the response of beef cattle to grub control. Cattle feeders consider an increased rate of gain of 0.15 lb. per day to be highly significant.

In the test reported by Ray L. Cuff, in the first 30 days the treated cattle gained 12.6 pounds each more than the untreated check cattle in the same feed lot. However, the *untreated* cattle gained 10.6 pounds each more than the treated cattle in the 30 days following the second treatment. There may be a number of reasons for such a reaction, one of which could be that since the cattle were from Texas, they probably were grubby in November. By February the grubs had matured and had dropped out of the untreated cattle.

In the 1943 test reported by Dickey, gains of the treated cattle were 0.22 lbs. higher than those of the untreated controls during the first 60 days of the test. Extremely unfavorable feed-lot conditions during the last 30 days caused both groups to lose weight. However, the treated cattle retained much of their weight advantage over the control group.

Some of the variations to be observed in the above table might be explained in a number of ways. For example, in one test the cattle lost an average of

DDT Fails to Remove Horsebots

H. S. TELFORD and PAUL D. HARWOOD,
Ashland, Ohio

A gelding weighing 1,405 lbs. was given 150 grams of DDT (Geigy) in two quarts of ground oats. The animal ate the mixture with relish and exhibited no noticeable toxic symptoms. The subject was then placed on light rations of ground oats, alfalfa hay and water. All manure was collected daily, washed, and carefully examined. After five days no bots were recovered, however on the fourth day one *Strongylus edentatus* (Looss) was taken. On the sixth day the animal was given nine drams of carbon disulfide in three capsules. Two days following administration one *Gasterophilus nasalis* (Linné) was recovered and on the third and last day of the experiment seven *G. nasalis* (Linné) and six *G. intestinalis* (DeGeer) were recovered.—3-1-45.

Cryolite and Some Organic Compounds to Control Corn Earworm and the Mexican Bean Beetle

LOYD W. BRANNON, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

The experiment reported herein was conducted to determine the comparative effectiveness of cryolite, phenothiazine, calcium salt of dinitro-o-cyclohexylphenol, and xanthone for the control of the corn earworm, *Heliothis armigera* (Hbn.), and the Mexican bean beetle, *Epilachna varivestis* (Muls.).

PROCEDURE.—The experiment was conducted on the Fordhook variety of bush lima beans, *Phaseolus lunatus macrocarpus*, at Norfolk, Va., in the fall of 1942. Each plot in the experiment contained four rows 44 feet long and 2½ feet apart. The plots for the various treatments were randomized in four blocks, the plot for each kind of treatment occurring once within each block. Thus each plot in the experiment was replicated four times. Each block also contained one untreated plot.

The sprays were applied with knapsack sprayers capable of maintaining a constant pressure of 150 pounds, and the dusts with bellows-type knapsack dusters. The beans were treated from each side of the row covering the under surface of the foliage. The quantities of insecticides applied per acre were determined by measuring the liquid left in the sprayers following treatment, and by weighing the dusters before and after treatment.

Three applications of each material were made—on September 10, 12, and 30. At the time of the first application the plans were blooming and setting small pods, the largest being about 2 inches long. This treatment, however, was of little value because of 1 inch of rainfall 9 hours later. On September 9 field counts showed a total of 61 eggs and 6 larvae of the corn earworm on 50 plants in various sections of the field. While these counts were being made it was observed that adults, eggs, and young larvae of the Mexican bean beetle were also very numerous on the plants. Additional beetles entered the field in large numbers on September 17 after an adjacent infested snap bean field had been plowed. The lima beans were picked on October 16 and 28.

RESULTS.—The data in table 1 show that micronized phenothiazine was approximately as effective as cryolite for the combined control of the corn earworm and the Mexican bean beetle. The micronized material was considerably more effective than a regular grade used in other tests. Cryolite diluted to contain 70 per cent of sodium fluoaluminate, previously recommended for control of the corn earworm (Brannon 1939, 1941), was more effective against both insects than a mixture containing 50 per cent of cryolite and 2 per cent of thiocyanate. Therefore this thiocyanate preparation is apparently not effective as an activator for cryolite. Although the calcium salt of dinitro-o-cyclohexylphenol gave some protection against the corn earworm, it proved ineffective against the Mexican bean beetle. Xanthone was not effective for control of either insect, and this insecticide caused some injury to the foliage.

Table 1.—Effectiveness of various insecticidal treatments for control of the corn earworm and the Mexican bean beetle on lima beans.

Insecticide Mixture	Rate Per Acre	Pods Injured by Earworm	Marketable Pods Per Plot	Estimated Foliage Injury by Beetles 3 Weeks After Third Application
	Pounds	*Number*	*Number*	*Per Cent*
Dusts (strength in talc)[1]				
Cryolite,[2] 70%	21	23	447	3
Cryolite, undiluted	13	35	437	14
Phenothiazine[3] 10%+sodium lauryl sulfate 1%	21	58	381	14
Calcium salt of dinitro-o-cyclohexylphenol 15%	19	46	345	41
Cryolite, 50%,+a thiocyanate[4] 2%	20	41	311	22
Xanthone 10%+sodium lauryl sulfate 1%	23	60	220	58
	Gallons			
Sprays (quantities in 50 gal. of water)				
Phenothiazine 4 lb.+sodium lauryl sulfate 2 oz.	95–100	39	464	2
Cryolite 4 lbs.	95–100	41	421	8
Untreated	—	51	217	66
Difference required for significance (at odds of 19:1)	—	—	78.3	13.7

[1] All percentages by weight.
[2] Domestic synthetic cryolite (Na_3AlF_6 83%) was used in all tests with this material.
[3] All samples of phenothiazine were micronized.
[4] Containing 50% of beta-thiocyanoethyl esters of aliphatic acids.

LITERATURE CITED

Brannon, L. W. 1939. Control of the corn earworm on Fordhook lima beans in eastern Virginia. U.S.D.A. Cir. 506.

Brannon, L. W. 1941. The corn earworm on lima beans and its control. U. S. Bur. Ent. and Plant Quar. E-547.

[1] In cooperation with the Virginia Truck Experiment Station.

A Dispenser for Methyl Bromide and Methyl Bromide-DDT Aerosols

DONALD F. STARR, EDWARD W. BAKER, and JUAN A. RAMIREZ, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Closed burettes for dispensing measured quantities of liquid methyl bromide under pressure have been used for several months at the Mexico City laboratory of the Bureau of Entomology and Plant Quarantine. The dispenser shown in figure 1, *A*, was made by sealing a second stopcock on top of an ordinary 10 ml. burette. The stopcocks were held in place against the pressure of the methyl bromide by rubber bands. Another type of burette was also used in which the pressure was maintained by means of a cork stopper held in place by a rubber band wound tightly around the top of the burette and over a pin in the stopper.

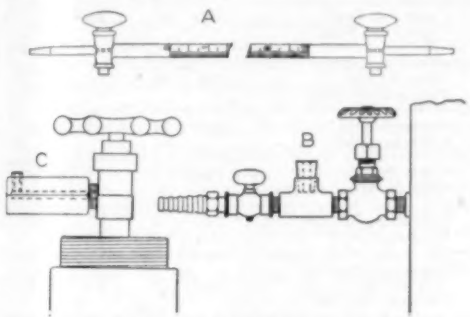


FIG. 1.—Methyl bromide dispenser: *A*, Burette; *B*, inlet to fumigating chamber; *C*, methyl bromide cylinder showing fitting for filling burette.

The stopcocks are lubricated with a starch gel prepared by stirring 10 to 15 grams of arrowroot, or corn starch suspended in 50 ml. of water into a solution of 20 ml. of glycerol and 50 ml. of water that has been heated to boiling, and continuing to heat the mixture until it becomes well thickened. A drop of cresol is added as a preservative. More starch makes the gel stiffer, and more glycerol makes it smoother. This lubricant, which is insoluble in methyl bromide, is more efficient in preventing leakage than are soluble lubricants.

The burette is filled from a small cylinder of commercial methyl bromide. A small fitting turned from brass, which screws onto the cylinder (Fig. 1, *C*), serves as connection to the burette. The tip of the burette, with both stopcocks closed, is inserted snugly into a small stopper in the fitting, the valve on the cylinder is opened, and then the lower stopcock is opened. A small volume of liquid methyl bromide immediately flows into the burette. The lower stopcock is then closed and the pressure released slightly at the top of the burette to sweep out the air. The burette may then be filled by opening the lower stopcock again. It will fill as full as needed, provided the air in the top of the burette has been swept out sufficiently by the methyl bromide vapor. With the stopcocks and the cylinder valve closed, the burette is removed from the stopper. The small volume of liquid between the lower stopcock and the valve is lost, but by careful design of the fitting to give a small bore and a small receptacle for the cork stopper, the loss may be reduced to less than 1 ml.

The volume of the burette from the lowest graduation mark to the lower stopcock was determined so that the entire quantity of methyl bromide in the burette could be measured into the fumigating chamber. The commercial methyl bromide had a specific gravity of 1.68 at 21° C., which was the value used in calculating the dosages by weight. Methyl bromide may be held in the burette for 3 or 4 days without loss.

The inlet to the fumigating chamber is shown in fig. 1, *B*. The burette tip fits snugly into a stopper in the inlet tube, and the methyl bromide passes through the valve into the chamber. The tube and valve are warmed with an alcohol burner to vaporize the methyl bromide completely, the valve is closed, and the burette is then removed.

Burettes smaller than 10 ml. may be used for delivering measured quantities of methyl bromide into flasks through a suitable inlet tube containing a stopcock.

The stoppered type of burette was used to dispense methyl bromide-DDT aerosols. The solutions were prepared by introducing weighed quantities of the insecticidal materials into the burette. With the burette calibrated to the stopcock, accurate concentrations were obtained by allowing the burette to fill to the desired mark. To avoid the possibility of insecticide entering the cylinder, the stopcock was manipulated so that there was always a positive flow of methyl bromide into the burette.

None of the solvents with higher vapor pressures were studied.—2-12-44.

New Distribution Records for the Mosquitoes of the Southeastern States in 1944

STANLEY J. CARPENTER,[1] ROY W. CHAMBERLAIN,[2] and JOHN F. WANAMAKER,[3] *Fourth Service Command Medical Laboratory, Fort McPherson, Georgia*[4]

King, *et al.* (1943), Middlekauff & Carpenter (1944), and Bradley, *et al.* (1944), presented collection records for 1942 and 1943, which add considerably to our knowledge of the distribution of the mosquito fauna of the Southeastern United States. Approximately 138 army installations submitted weekly collections of mosquitoes to the Fourth Service Command Medical Laboratory during 1944, and the number of specimens identified from January through October totaled 452,782 adults and 152,724 larvae. A total of 58 species was represented in the collections. The army installations at which collections were made are distributed by states as follows: Alabama—14, Florida—53, Georgia—22, Mississippi—16, North Carolina—12, South Carolina—14, and Tennessee—7.

Seven new state records comprising six species have been added by army personnel in the Fourth Service Command during 1944, and are presented in this paper together with 31 additional new locality records representing 16 species (Table 1). Larval

[1] Major, Sanitary Corps, Army of The United States.
[2] 2nd Lieutenant, Sanitary Corps, Army of The United States.
[3] 2nd Lieutenant, Sanitary Corps, Army of The United States.
[4] It is desired to express appreciation to the following personnel for assistance: Miss Leonora Peeples SP-4, Miss Elaine Smith SP-4, Mrs. Jeanne Spence SP-4, Miss Rosemary Baker SP-3, Miss Winona Gilstrap SP-3, Louis M. Roth, 2nd Lieutenant, Sn. C., and Sergeant Daniel Sudia.

Table 1.—New distribution records for mosquitoes of the southeastern United States in 1944, arranged according to species, locality, date, number and sex. The collections are listed according to type indicated by the following symbols: (T)—light trap (New Jersey type); (R)—resting stations; (B)—biting; and (L)—larval.

Species and Locality	Inclusive Dates of Collections	Specimens and Collection Methods
Aëdes atropalpus		
Moore General Hospital Swannanoa, N. C.	June 19 Aug. 9 Sept. 18 Oct. 3	3 (L) 2♂[2] (Reared) 8 (L) 1♂ (Reared)
Aëdes cinereus		
Marianna, AAB Jackson County, Fla.[1]	Oct. 2	2♂[2] (T)
Greenville AAF Washington County, Miss.	June 2	1♂[2] (T)
Camp Shelby Forest County, Miss.[1]	May 31	2 (L)
Laurinburg-Maxton AAB Robeson County, N. C.	May 22	1♂ (T)
Camp Mackall Richmond County, N. C.	May 3	1♂[2] (T)
Moore General Hospital Swannanoa, N. C.	March 22 March 23 March 30 April 3, 10	3♂[2] (Reared) 12 (L) 3 (L) 3 (L)
Camp Croft Spartanburg County, S. C.	April 28	1♂[2] (T)
Aëdes infirmatus		
Aliceville Internment Camp Pickens County, Ala.	March 23	1♂ (R)
Aëdes mathesoni		
Camp Blanding Bradford County, Fla.	Aug. 14	1♀[3] (R)
Tyndall Field Panama City, Fla.	Aug. 24	1♂, 1♀[3] (T)
Aëdes sollicitans		
Napier Field Dothan, Ala.	July 12, 17	2♀ (T)
Camp Sibert Attala, Ala.	June 28	1♀ (T)
Fort Benning Columbus, Ga.	June 23	1♀ (T)
Jackson AAB Jackson, Miss.	Aug. 28	1♀ (T)
Mississippi Ordnance Plant Flora, Miss.	May 12	1♀ (T)
Aëdes sticticus		
Camp Sibert Attalla, Ala.	May 30 June 15	1♀ (R) 1♀ (B)
Camp Shelby Hattiesburg, Miss.	March 7	4 (L)
Myrtle Beach AAF Myrtle Beach, S. C.	March 22 April 17, 19 April 26 May 3	1♀ (T) 1♂, 2♀ (T) 1♀ (R) 1♂ (T)
Shaw Field Sumter, S. C.	April 6	1♀ (R)
Aëdes thibaulti		
Camp Tyson Paris, Tenn.[1]	May 6	1♀ (R)
Aëdes trivittatus		
Laurinburg-Maxton AAB Maxton, N. C.	June 30	1♀ (T)
Anopheles albimanus		
Boca Raton AAF Boca Raton, Fla.	May 16	1 (L)
Anopheles georgianus		
Orlando AAFTAC Orlando, Fla.	May 1	1 (L)
Anopheles walkeri		
Camp Sibert Attalla, Ala.[1]	May 31	1♀ (T)
Jonesboro, Ga. Clayton County	Nov. 1, 3, 8	50♀ (B)
Culex nigripalpus		
Camp Van Dorn Centerville, Miss.	April 3	1♀ (R)
Camp Sutton Monroe, N. C.[1]	Sept. 1	1♀ (R)
Greenville AAB Greenville, S. C.	Aug. 16	1♂[2] (T)
Culex pilosus		
Camp Van Dorn Centerville, Miss.	July 10	1♂[2] (R)
Orthopodomyia alba		
Tyndall Field Panama City, Fla.[1]	Oct. 20	1♀ (T)
Columbus AAF Columbus, Miss.	July 14	1♀ (T)
Camp McCain Grenada, Miss.	June 19	1♀ (T)
Laurinburg-Maxton AAB Maxton, N. C.	July 8 Oct. 9	1 (L) 1♀ (T)
Psorophora cyanescens		
Tyndall Field Panama City, Fla.[1]	Sept. 18	1♀ (T)
Psorophora horrida		
Fort Benning Columbus, Ga.	Sept. 12–21 Oct. 5	5♂, 3♀[4] 25 (L)[4]
Psorophora howardii		
Aliceville Internment Camp Aliceville, Ala.	Aug. 11	1♀ (T)
Psorophora varipes		
Camp Shelby Hattiesburg, Miss.	March 30 April 7	10 (L) 27 (L)

[1] Previously unrecorded from the state.
[2] Identified by genitalia.
[3] Checked by A. Stone, U. S. National Museum, Washington, D. C.
[4] Specimens reared from eggs at Fort Benning, Georgia, by Lt. Charles B. Eaton.

records of *Aëdes sticticus* (Meig.) and *Psorophora varipes* (Coq.) from Camp Shelby, Mississippi, and *Psorophora horrida* (D. and K.) from Fort Benning, Georgia, are included since only adults of these species have previously been taken by army personnel in this region.

Literature Cited

Bradley, G. H., R. F. Fritz and L. E. Perry, 1944. Additional Mosquito Records for the Southeastern States. Jour. Econ. Ent. 37(1): 109.

King, W. V., L. Roth, J. Toffaleti and W. W. Middlekauff, 1943. New Distribution Records for the Mosquitoes of the Southeastern United States During 1942. Jour. Econ. Ent. 36(4): 573–7.

Middlekauff, W. W., and S. J. Carpenter. 1944. New Distribution Records for the Mosquitoes of the Southeastern United States in 1943. Jour. Econ. Ent. 37(1): 88–29.

Strange Oviposition Habits of a Treehopper

S. W. FROST, *The Pennsylvania State College*

In the fall of 1944, numerous northern spy apples were received from an orchard in Wayne County, Pennsylvania, showing oviposition scars of a treehopper of the genus *Ceresa* or *Stictophora*. The conditions which stimulated this unusual habit could not be determined. The injury appeared in a commercial orchard free from clover, alfalfa and weeds. Each of the injured fruits showed from 6 to 10 crescent-like scars typical of the oviposition habits of treehoppers of these genera. The incisions were made just beneath the skin of the apples appearing at first like thumb-nail cuts. Later the eggs became more plainly visible through the skin. These scars were not placed in regular rows, as is commonly the case with *Ceresa bubalus* when ovipositing on apple twigs, but were scattered over the surface of the fruit. From 8 to 10 eggs were deposited in each incision, the eggs being placed adjacent to each other and converging towards the slit. The fruits bearing eggs were placed in a chamber to rear the nymphs but the apples rotted before the eggs hatched.

The nymphs and adults of *Ceresa* and *Stictophora* prefer to feed upon succulent vegetation such as leguminous plants, weeds and certain vegetables. Hodgkiss (1910) found that *Ceresa taurina* fed upon pear fruits in breeding cages. Poisson (1937) was unable to induce *Ceresa bubalus* to feed on pear.

Normally *Ceresa* and *Stictophora* oviposit in two or three-year-old twigs, although they may oviposit in succulent plants. Hodgkiss (1910) reported that the eggs of an unidentified species of *Ceresa* were deposited within the petioles of the leaves of weeds.

FIG. 1.—An apple showing oviposition scars of a treehopper.

Under normal conditions the eggs of treehoppers, deposited within fruit, would probably never develop because the species hibernates as eggs and the fruit would rot long before the nymphs could develop.

Although this unique ovipositing habit has not been recorded to my knowledge, it has been observed by a few entomologists. In the photographic files of the extension entomologist at the Pennsylvania State College, there is an excellent picture of this type of injury. A careful search of the literature for the past fifty years failed to reveal any accounts of injury of this kind. The detailed accounts of Hodgkiss (1910), Yothers (1934) and Poisson (1937) make no mention of such injury.—2-21-45.

LITERATURE CITED

Hodgkiss, H. E. 1910. Apple and pear membracids. N. Y. Agr. Expt. Sta. Geneva Tech. Bul. 17: 81–112.

Poisson, R. 1937. Quelques observations biologiques et morphologiques sur *Ceresa bubalus* (Fab.) Bul. Soc. Sci. Bretague, Rennes 14: 32—50.

Yothers, M. A. 1934. Biology and control of treehoppers injurious to fruit in the Pacific North West, U. S. D. A. Tech. Bul. 402.

Insecticidal Tests for Control of Green Clover Worm and *Autographa* on Snap Beans

LOYD W. BRANNON, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

In the fall of 1942 there were severe outbreaks of the green clover worm, *Plathypena scabra* (F.), and *Autographa* sp.[2] in many fields of snap and lima beans and soybeans in eastern Virginia (Fig. 1). In some fields the plants were almost defoliated, and the insects were causing considerable damage to the pods. Previous work by Marcovitch & Stanley (1941) had indicated the value of cryolite for control of loopers on beans.

Many growers in eastern Virginia were already treating their beans with cryolite dust for control of the corn earworm, *Heliothis armigera* (Hbn.). The experiment reported herein was conducted in the fall of 1942 to determine as quickly as possible the effectiveness of the cryolite treatments against the loopers, and to test the value of various other insecticidal dust mixtures (Table 1) for their control.

The experiment was conducted on a wax variety of snap beans. Plots containing four rows 44 feet long and 30 inches apart were used. Treated and untreated plots were duplicated in the field, the latter being situated alongside of the former.

The insecticides were applied with bellows-type knapsack dusters from each side of the row and covered the under surface of the foliage. A single application was made on September 11. At this time the plants were just beginning to bloom.

The results as given in table 1 show that cryolite was the most effective insecticide tested, giving 86 to 92 per cent reduction in the number of live loopers present 72 hours after treatment. The pyrethrum-sulfur mixture caused 90 per cent reduction of the loopers but did not protect the foliage so well as did cryolite. Table 1 shows further that, although the looper population on untreated plots was relatively small, averaging less than one per plant, the insects caused considerable damage to the foliage.

The results confirm the findings of Marcovitch & Stanley relative to the effectiveness of cryolite for looper control. Since the author (Brannon 1941) has

[1] In cooperation with the Virginia Truck Experiment Station.

[2] Identified by Carl Heinrich, Division of Insect Identification, Bureau of Entomology and Plant Quarantine. Of 17 specimens submitted from collections made on Sept. 16 and Oct. 12 and 20, 9 were identified as *Autographa* sp. and 8 as *Plathypena scabra* (F.),

Table 1.—Looper populations and injury to snap beans dusted with insecticides on Sept. 11, 1942.

Insecticide Mixture[1]	Rate Per Acre	Larvae Surviving on 40 Plants[2] After 72 Hours		Foliage Destroyed by Oct. 1	
		Treated	Not Treated	Treated	Not Treated
	Pounds	*Number*	*Number*	*Per Cent*	*Per Cent*
Cryolite+talc (Na_3AlF_6 70%)	22	2	25	2	42
Cryolite,[3] undiluted	12	3	22	7	49
Pyrethrum powder+sulfur (pyrethrins 0.5%)	19	2	20	42	42
Cryolite+thiocyanate[4]+talc (Na_3AlF_6 50%, thiocyanate 2%)	22	8	24	19	42
Sulfur 100%	19	17	26	42	47
Derris+pyrethrum+talc (rotenone 0.2%, pyrethrins 0.1%)	25	22	24	44	44
Xanthone[5] 10%+talc 90%	19	29	30	47	47
Derris+talc (rotenone 0.75%)	13	26	26	47	47

[1] All percentages by weight.
[2] 5 random plants from each row of duplicate 4-row plots.
[3] Domestic synthetic cryolite (Na_3AlF_6 83%) was used in all tests with this material.
[4] Containing 50% of beta-thiocyano ethyl esters of aliphatic fatty acids and 50 per cent of petroleum distillate.
[5] Commercial material.

Fig. 1.—Field of snap beans showing damage caused by the green clover worm, and *Autographa sp.*

reported on the use of cryolite for control of the corn earworm, and Brannon & Howard (1936) have shown that sulfur in combination with cryolite is effective for the control of the Mexican bean beetle, *Epilachna varivestis* Muls., and powdery mildew, this mixture may thus prove of value on fall beans in eastern Virginia. Development of such all-purpose insecticides appears to be of prime importance at this time when every effort is being directed towards increasing the yield and quality of foodstuffs with a minimum of labor and material.

Literature Cited

Brannon, L. W. 1941. The corn earworm on lima beans and its control. U. S. Bur. Ent. and Plant Quar. **E-547.**

Brannon, L. W., and N. F. Howard. 1936. Observations on control of Mexican bean beetle in association with powdery mildew disease on snap beans. Jour. Econ. Ent. **29**(5): 1028.

Marcovitch, S., and W. W. Stanley. 1941. The tomato fruitworm in Tennessee. Tenn. Agr. Expt. Sta. Bul. **174.**

Collection Records of *Culex tarsalis* in Army Camps in the Southeastern States During 1942, 1943 and 1944

Stanley J. Carpenter,[1] *Fourth Service Command Medical Laboratory, Fort McPherson, Georgia*

Culex tarsalis (Coq.) is abundant throughout most of the midwestern and western United States and western Canada where it occurs from spring until late fall. The species extends eastward to the Mississippi Valley and into the eastern states in diminishing numbers. The occurrence of larvae and adults of *C. tarsalis* in the Mississippi Valley and in the eastern states is limited mostly to the late summer and early fall months.

Hammon, Reeves and associates (Hammon *et al.*, 1941, 1942, 1943) have demonstrated repeatedly the infection of *Culex tarsalis* under natural conditions with the virus of St. Louis and western equine encephalitis and have shown that this species is capable of transmitting the infection. Reeves & Hammon (1944) found *C. tarsalis* to feed readily on domestic animals and birds, a fact of considerable importance since many of these may serve as inapparent reservoirs for encephalitis viruses (Hammon *et al.*, 1942, 1943).

Due to the well-known medical importance of this species, its seasonal and geographical distribution in the southeastern United States, as indicated by collections in army camps, is presented in this paper. The only 1942 records for this species in army camps in the Fourth Service Command were for Camp Tyson, Tennessee. Bradley, *et al.* (1944) list additional records during 1943 for Cordova and Millington in Tennessee, and for Pensacola, Florida. The locations of collections of this species taken during 1942, 1943 and 1944, at army camps in the Fourth Service Command are given in table 1, and collection records for each camp in which it was taken during 1943 and 1944, are also shown in table 1. *Culex tarsalis* has been collected by army personnel in all states comprising the Fourth Service Command except North Carolina.—1-29-45.

[1] Major, Sanitary Corps, Army of The United States.

Table 1.—Collections of *Culex tarsalis* (Coq.) in the Southeastern United States during 1943 and 1944, arranged according to locality, date, number and sex. The collections are listed according to type indicated by the following symbols: (T)—light trap (New Jersey type); (R)—resting station; (B)—biting; and (L)—larval.

Locality	Collections Made During 1943		Collections Made During 1944	
	Dates of Collections	Specimens & Collection Methods	Dates of Collections	Specimens & Collection Methods
ALABAMA				
Maxwell Field Montgomery County			Oct. 19	1♂(T)
Fort McClellan Calhoun County	Sept. 7	1♀(T)		
Camp Sibert St. Clair and Etowah Counties	Sept. 20, 24	5♀(T)		
FLORIDA				
Marianna AAB Jackson County	Sept. 27	1♀(T)		
Tyndall Field Bay County			Sept. 18	1♀(T)
GEORGIA				
Fort Benning Muscogee County			Oct. 12	1♀(R)
Camp Wheeler Bibb County	Sept. 20 Sept. 24	1♀(T) 1♀(T)		
MISSISSIPPI				
Clinton POW Camp Hines County	Sept. 21	1♀(R)	Sept. 20 Oct. 18	1♀(T), 1♀(R) 1♂(T)
Columbus AAF Lowndes County			Sept. 8, 11 Oct. 11, 13 Oct. 16, 18	2♀(T) 3♀(T) 2♂(T)
Como POW Camp Panola County	Sept. 13, 17 Sept. 20, 24 Sept. 27 Oct. 6	16♀(T) 5♀(T) 1♀(R) 1♂, 1♀(T)	Sept. 6 Sept. 11 Sept. 22, 29 Oct. 10, 11 Oct. 20 Oct. 27	2♀(T) 3♀(T), 1♀(R) 2♀(T) 1♀, 1♂(T) 1♂, 1♀(T) 1♂(T)
Greenville AAF Washington County	Oct. 16	1♀(R)		
Greenwood AAF Carroll County	Sept. 13 Sept. 20	1♀(T) 1♀(T)	Oct. 11 Oct. 27	1♂(T) 1♀(T)
Gulfport Field Harrison County	Sept. 20, 24	3♀(T)	Oct. 9 Oct. 13	1♀(T) 1♀(T)
Keesler Field Harrison County	Sept. 24	1♀(T)	Sept. 11 Oct. 9 Oct. 11	1♀(T) 2♀(T) 1♂, 1♀(T)
Laurel AAB Jones County	Oct. 22	1♀(R)		
Camp McCain Grenada and Montgomery Counties	Sept. 13 Sept. 27	1♀(T) 1♀(T)	Oct. 11	3(L)

Table 1.—*continued*

Locality	Collections Made During 1943		Collections Made During 1944	
	Dates of Collections	Specimens & Collection Methods	Dates of Collections	Specimens & Collection Methods
Miss. Ord. Plant Flora Madison County	Sept. 13 Sept. 20	1 ♀ (T) 1 ♀ (T)	Oct. 24	2(L)
Camp Shelby Forrest County	Sept. 24 Sept. 27 Oct. 7 Oct. 9	1 ♀ (T) 2 ♀ (T) 1 ♀ (T) 1(L)	Oct. 6 Oct. 9 Oct. 14	1 ♀ (T) 1 ♀ (T) 1 ♀ (T)
Camp Van Dorn Wilkinson County	Sept. 27	1 ♀ (T)	Oct. 16 Oct. 17	1 ♂ (R) 1 ♀ (R)
South Carolina				
Columbia AAF Lexington County			Oct. 3	1 ♀ (B)
Shaw Field Sumter County	Nov. 5	1 ♀ (T)		
Tennessee				
Dyersburg AAB Lauderdale County	Sept. 16	1 ♀ (R)		
Hq. Second Army Memphis Shelby County	Sept. 13	1 ♀ (R)		
Municipal Airport Memphis	Sept. 24 Oct. 7	1 ♀ (T) 1 ♀ (R)	Sept. 8 Sept. 15 Sept. 29	2 ♀ (T) 1 ♀ (T) 1 ♀ (T)
Nashville AAC Davidson County	Oct. 4	1 ♂ (R)		
Smyrna AAF Rutherford County	Aug. 24 Sept. 20, 24 Sept. 29 Oct. 1 Sept. 23	1 ♀ (T) 6 ♀ (T) 1 ♀ (T) 1 ♂ (T) 1 ♀ (R)	Sept. 8	1 ♀ (T)
Camp Tyson Henry County			Sept. 11	1 ♀ (T)

Literature Cited

Bradley, G. H., R. F. Fritz and L. E. Perry. 1944. Additional mosquito records for the southeastern states. Jour. Econ. Ent. 37(1): 109.

Hammon, W. McD., W. C. Reeves, B. Brookman and E. M. Izumi. 1941. Isolation of the Virus of Western Equine and St. Louis Encephalitis from *Culex tarsalis* Mosquitoes. Science 94: 328.

Hammon, W. McD., H. W. Lundy, J. A. Gray, F. C. Evans, F. Bang and E. M. Izumi. 1942. A Large-Scale Serum-Neutralization Survey of Certain Vertebrates as Part of an Epidemiological Study of Encephalitis of the Western Equine and St. Louis Types. Jour. Immunology 44: 75–86.

Hammon, W. McD., W. C. Reeves and M. Gray. 1943. Mosquito Vectors and Inapparent Animal Reservoirs of St. Louis and Western Equine Encephalitis Viruses. Am. Jour. Public Health 33: 201–7.

King, W. V., L. Roth, J. Toffaleti and W. W. Middlekauff. 1943. New distribution records for the mosquitoes of the southeastern United States during 1942. Jour. Econ. Ent. 36(4): 573–7.

Reeves, W. C., and W. McD. Hammon. 1944. Feeding habits of the proven and possible vectors of western equine and St. Louis encephalitis in the Yakima Valley, Washington. Am. Jour. Tropical Medicine 24(2): 131–4.

Boric Acid as a Stomach Poison for the German Cockroach[1]

O. S. BARE, *Nebraska Agricultural Experiment Station, Lincoln*

Investigations concerned with the development of a satisfactory poison bait for the German cockroach, *Blatella germanica* (Linne.) were conducted during 1943 and 1944. An effort was made to find bait materials more attractive than ordinary foods, poisons that were non-repellent, and attractants that would increase the attractiveness of baits.

MATERIALS: The bait materials tested were powdered skim milk, butter, honey, powdered confectioners sugar, and malt flours of barley, wheat and sorghum. Sodium fluoride, borax and boric acid were tried as poisons incorporated in the various baits. Butyric acid, malt extract and stale beer were tried as attractants because of the belief that stale dairy products and fermented materials are attractive to cockroaches.

METHODS: In these tests five adult German cockroaches and an equal number of nymphs of assorted sizes were placed in a battery jar with a supply of water, food and the poison bait. Five such jars with the same poison bait were used in each test. This was repeated three times, thus giving a total of 15 jars and 150 insects for each bait. Adult cockroaches were divided approximately equally as to sex and at least one female with an egg capsule near hatching was included in each jar. Two tests also were made in which from 50 to 100 German cockroaches of all ages were confined in a large constant temperature chamber (3×3×4 ft.) provisioned with an assortment of common foods, water and poison bait.

RESULTS: Butter, honey and powdered confectioners sugar were the most promising bait materials tried. However, none of these were significantly more attractive than foods often available. Of the insecticides tried, boric acid was the only one that was both effective and non-repellent at killing strength. Baits containing sodium fluoride were highly repellent. Borax in baits was not repellent, but its toxicity was very low. None of the attractants tried showed significant value in increasing attractiveness of the poisoned baits. The rate of kill of baits containing stale beer and malt extract was increased up to the 70-per cent point, but the time necessary to complete the kill was not significantly different in baits either with or without attractants.

A bait composed of 10 per cent powdered boric acid and 90 per cent powdered confectioners sugar gave an 80 per cent kill in an average of 13 days and 100 per cent kill in 21 days. A half and half mixture of honey and butter plus 10 per cent by weight of powdered boric acid gave 80 per cent kill in 9 days and 100 per cent kill in 16 days. Nymphs hatching in the jars containing these baits died in the first instar, whereas those hatching in check jars developed normally. Results of the tests made in the large constant temperature chambers corresponded closely to those obtained in the tests with battery jars.

CONCLUSIONS: Boric acid is an effective stomach poison for the German cockroach and at proper strength does not render baits repellent. A bait of 10 per cent powdered boric acid and 90 per cent powdered confectioners sugar is eaten readily even when other common foods are available, and the same is true of a butter-honey bait containing 10 per cent boric acid by weight. Although slow in action, these poison baits give excellent control when exposed over a period of several weeks, and their general availability, low cost, and relatively non-poisonous nature render them particularly suitable for home use or where the use of quicker acting and more violent poisons may be inadvisable.—3-12-45.

[1] Published with the approval of the Director as Paper No. 373, Journal Series, Nebraska Agricultural Experiment Station.

Biology and Control of the Lima Bean Vine Borer

LOYD W. BRANNON, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

Although the description and general notes concerning damage caused by the lima bean vine borer, *Monoptilota pergratialis* (Hulst)[2] are contained in the literature (Chittenden 1900, 1902), no records have been found of previous investigations on the seasonal history or insecticidal control of the pest. The studies reported herein were conducted at Norfolk, Va., from 1936 to 1942, inclusive.

FEEDING HABITS AND NATURE OF INJURY.—Damage to pole lima beans by the lima bean vine borer is caused by the feeding of the larva inside the stem or stalk of the plant. The moth deposits its eggs on the leaves and stem of the plant. Shortly after hatching, the young larva begins to feed on the leaf, usually around the larger veins at the stem end. Injury to the leaf is characterized by a light shaving or skinning of the lower epidermis. Accumulations of frass, webbing, and excrement are usually present where feeding has occurred.

After entering the stem of the plant the insect causes a gall-like enlargement or swelling to form. The gall first appears as a slight enlargement of the stem. By the time the insect has become full grown the gall has attained a size of approximately 1.5 inches in length by 0.5 inch in diameter (Fig. 1). The galls may occur at any point from the surface of the ground to near the tip of the vine. The damage varies with the position of the gall and the vigor of the plant. When the gall is formed on the main stem, very little damage usually occurs, unless two larvae are present in the same gall or one gall is formed just above another. However, when the gall is formed at the junction of the main stem and a side branch, or on a small branch near the tip, that part of the plant above the gall usually wilts and dies. Plants weakened by galls are also easily broken by the wind and killed. Observations made by the writer indicate that the insect prefers a large-seeded variety of lima beans to a small-seeded variety. This preference is apparently due to the larger stem of the former.

SEASONAL HISTORY.—The lima bean vine borer passes the winter as a mature larva enclosed in a silken cocoon covered with dirt. The cocoons are formed in the fall and are situated on or near the soil surface. In the latitude of eastern Virginia, pupation occurs during the first part of May and the first moths emerge about the middle of May. Emergence continues to the middle or latter part of June. Egg laying begins during the latter part of May. The eggs are laid singly on the leaves and stems of the plants, and they hatch in 2 to 6 days. The young larvae feed on the leaves for 4 to 7 days

[1] In cooperation with the Virginia Truck Experiment Station.
[2] *Monoptilota nubilella* Hulst.

before boring into the stem. As the larva feeds and grows it causes a gradual enlargement of the stem.

When ready to pupate, the larva bores a round exit hole through the wall of the gall, usually at the lower end, and drops to the ground, where it spins a silken cocoon. The pupation period lasts about 15 days. Emergence of first-brood moths occurs during the latter part of July. The length of the developmental period from egg to adult is about 50 days. First-brood moths begin laying eggs within 24 hours after emergence. Larvae of the second brood reach maturity in September and October. In eastern Virginia two broods develop in a season.

CONTROL.—Previous recommendations for control of the lima bean vine borer contain the suggestion that larvae be cut out of any galls formed on the main stem of the plant, and that galls present

FIG. 1.—Pole lima bean vines showing galls caused by the lima bean vine borer.

on terminal shoots or side branches be cut off and destroyed. From observations made by the writer it appeared that the mechanical injury to the vine resulting from this method tended to increase rather than alleviate the damage; also, this procedure would not be practicable in other than very small plantings of beans.

As the larvae feed on the foliage for 4 to 7 days before boring into the stems of the plants, it was believed that control with insecticides might be feasible.

The initial tests for control reported herein were made with cryolite dust and spray. The dust mixture contained 70 per cent of sodium fluoaluminate prepared by mixing a commercial cryolite preparation (89 per cent) with sulfur. Applications were made with a bellows-type knapsack duster. The spray mixture contained 3.8 pounds of the commercial cryolite and 2 pounds of wettable sulfur per 50 gallons of water, and it was applied with a knapsack sprayer capable of maintaining a constant pressure of 150 pounds. The bean plants were treated from each side of the row, every effort being made to secure thorough coverage of both foliage and stems.

In this experiment three plots of a large-seeded variety of pole lima beans were used. Each plot contained three rows 16 feet long and 4 feet apart. An untreated plot was situated between two treated plots. Dust and spray applications were made on June 6, 13, and 25, and July 9, the first treatments being applied 2 days prior to hatching of the first egg found on the plants and the final treatments 19 days before the first picking of the bean crop. At the time of the first applications the plants contained several sets of trifoliate leaves but had not sent out their runners.

On July 16 there were 59, 60, and 63 plants in the dusted, sprayed, and untreated check plots, respectively. The vine borer galls numbered 19 on the dusted plots, 28 on the sprayed plot, and 59 on the untreated plot. The dust therefore gave about 68 per cent control and the spray about 52 per cent.

Fall plowing and cultivation should aid in the control of the lima bean vine borer by destroying the larvae which pass the winter in cocoons on or near the surface of the soil.—1-20-45.

LITERATURE CITED

Chittenden, F. H. 1900. Some Insects Injurious to Garden Crops. U. S. Div. Ent. Bul. (n.s.) **23**: 9–17.

Chittenden, F. H. 1902. Some Insects Injurious to Vegetable Crops. U. S. Div. Ent. Bul. (n.s.) **33**: 102–3.

Laboratory Rearing of *Aëdes atropalpus*

HELEN LOUISE TREMBLEY, *National Institute of Health, Bethesda, Maryland*

In October 1944 Doctor Newell E. Good, entomologist with the U. S. Public Health Service, furnished us with larvae of *Aëdes atropalpus* (Coquilett) which he had collected from pot-holes in the rocks along the Potomac River at Chain Bridge, D. C., and since that time, we have reared this species continuously and abundantly.

Due to the lack of published information on the laboratory rearing of *Aëdes atropalpus*, the following brief notes are presented.

According to Matheson (1944): "This species is locally distributed throughout the eastern United States, and is recorded from Arkansas, Oklahoma, Arizona, New Mexico, and Texas. The larvae are found in rock holes along streams and waterfalls."

Rearing procedure follows in general that described for *A. aegypti* by the writer (1944). Immature and mature mosquitoes have been reared in a room where temperature and humidity varied—74° to 84° F. with 25 to 100 per cent relative humidity. High humidity favors the longevity of adults, which die in a day or two when the relative humidity remains below 60 per cent and access to water is denied. Adults have been kept in cages as large as 2×2×2 feet, and as small as 10×10×10 inches. Emergence, mating, feeding, and oviposition occur in such cages. Lantern globe rearing has not been attempted.

There is considerable latitude in the choice of food and water. Food for adults has consisted of sliced apple or dextrose solution, and for larvae, of either ground dog food, powdered dog food, or whole oats cut in half. Tap water is used for raising larvae, although at first distilled water and water with nutrient salts were used. The water may become very shallow and foul without apparent injury to larvae, but a heavy scum covering the entire surface of the water will cause mortality. The pH runs from nearly neutral to 5.5.

Oviposition has begun as early as two days after a blood meal, and about 100 eggs were deposited by each female. They are laid preferably on open

water, although females will oviposit on damp filter paper. Eggs hatch in about 24 hours, with a comparatively high per cent of the eggs hatching. Preliminary observations indicate that eggs remain viable for at least two months if they are dried slowly on filter paper soon after oviposition.

Pupation occurs within 9 days to 2 weeks. Pupae can be separated by size, the females being larger than males of the same lot.

Adults begin to emerge in about 30 hours. Females have not engorged readily on blood until after they have fed on fruit or dextrose for ten days or two weeks, although in some instances they have been induced to feed earlier. Man, chick, and white rat have been the only hosts tried, and they appear to be equally acceptable. Interrupted feedings are practicable. It is possible to have females in individual containers feed to repletion after as many as four interruptions.—3-14-45.

LITERATURE CITED

Matheson, R. 1944. Handbook of the Mosquitoes of North America. Second Edition. Comstock Publishing Company. Ithaca, N. Y.

Trembley, H. L. 1944. Mosquito Culture Technique. Mosquito News **4**(4): 103–19.

The Use of a "Rototiller" for Application of Soil Fumigants[1]

H. E. MORRISON, DON C. MOTE and R. N. LUNDE, *Oregon Agricultural Experiment Station, Corvallis*

The symphylid *Scutigerella immaculata* Newport has been under investigations in Oregon for a number of years. Many materials have been tested and the most promising results have been obtained from partial soil sterilizing agents. Limiting factors for general use of these materials have been (1) the prohibitive material costs, (2) prohibitive labor costs involved in application by the injection method, and (3) the necessity of having soils in a friable condition (elimination of clods) for efficient control.

The approach to the symphylid problem has accordingly resolved itself into a development of a better method of applying fumigants into the soil. A "rototiller" was obtained and equipped with a small gasoline motor and air compressor. This was used to atomize fumigants into the soil in the same manner as the ordinary paint sprayer. Applications were made immediately behind the rototiller tines.

This procedure resulted in preparation of the seed bed (plowing, disking, and harrowing) and soil sterilizing with one operation. Maximum area covered with the 18-inch rototiller was a quarter-acre per hour. The soil in this instance was in excellent condition for working and once over with the rototiller was sufficient.

Results of these investigations have been very encouraging. Some mechanical improvements still require attention but it is indicated that the amount of partial soil sterilizing agents may be reduced by 50 per cent with satisfactory symphylid control.

Rototilling of soil without additions of soil sterilizing agents has made it possible to raise normal crops in soils heavily infested with symphylids. The probable explanation for this is that symphylids were thoroughly scattered throughout the plot and not able to establish themselves about the roots of the germinating plants. The plants were thus able to establish themselves with a good root system and able to withstand later symphylid attack. There was no reduction in symphylid population in the plot where the rototiller was used.—3-13-45.

[1] Published as Technical Paper No. 458 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution of the Departments of Entomology and Agriculture Engineering.

A Synonym of *Cerosipha subterranea* (Mason)

E. O. ESSIG, *Univ. of California, Berkeley*

The guayule aphid, *Cerosipha californica* Essig, has unfortunately proved to be a synonym of *Rhopalosiphum subterraneum* Mason. It is one of those borderline species that may be relegated to one of two genera, but since the antennae are nearly always 5-segmented it may as well be placed in the genus *Cerosipha*. The species appears to be an inhabitant of temperate, subtropical, and tropical regions and has been reported to occur in Alabama, California, Hawaii, Illinois, Indiana, Maryland, Missouri, North Carolina, Ohio, Porto Rico, South Carolina, Texas, and Virginia. The specimens from Porto Rico were taken on roots of rice at Rio Piedras by L. Martorell, Dec. 14, 1943 and forwarded to me by Dr. G. N. Wolcott. The known host plants are the roots of beans (butter), celery, cotton, crabgrass, cudweed, guayule, life-everlasting, iris, *Oenothera laciniata*, okra, prune (resting on leaves-casual?), potato, rice, and tomato. I am indebted to Professor Miriam A. Palmer for calling my attention to this error.—2-3-45.

LITERATURE CITED

Mason, P. W. 1944. A new root aphid (Homoptera: Aphiidae). Proc. Ent. Soc. Wash. **36**(6): 166–7.

Essig, E. O. 1944. A new aphid on guayule and notes on other species of *Cerosipha*. Hilgardia **16**(4): 177–84.

Orthopodomyia alba in Kentucky

JAMES B. KITZMILLER,[1] *Ft. Knox, Ky.*

A series of *Orthopodomyia alba* Baker larvae has been collected by the writer and Corporal Thomas E. Potts at Fort Knox, Kentucky. This is believed to be a new record for this species for the state of Kentucky.

Twenty-two larvae were taken on 22 and 24 August 1944, from a tree stump on the Military Reservation, which had held water continuously since the spring in spite of a very dry season. *Orthopodomyia signifera* and *Aedes triseriatus* were taken with *Orthopodomyia alba* on both occasions.

Specimens preserved in the collection at Fort Knox agree essentially with descriptions given by King, *et al.*, "Mosquitoes of the Southeastern States," 1942. The sclerotic plates on abdominal segments VI, VII and VIII are lacking, lateral abdominal hairs are double or triple on segments I and II, the anal segment is incompletely ringed by the sclerotic plate, the tuft of the air tube has three or four branches, and the lateral hair of the anal segment is double or triple.—1-29-45.

[1] 1st Lieutenant, Sn. Corps A.U.S., Entomologist, Ft. Knox, Ky.

DDT to Control *Scutigerella immaculata*[1]

H. E. MORRISON, DON C. MOTE and W. B. RASMUSSEN, *Oregon Agricultural Experiment Station, Corvallis*

Randomized and replicated plots of one thirtieth acre in size were used for trials against the symphylid *Scutigerella immaculata* Newport during 1944. DDT dust (3 per cent Geigy) was used as a seed treatment in these tests and was applied by mixing 4 ounces of DDT dust to 5 ounces of bean seed (variety Bountiful). This mixture was drilled in a 40 foot row with a Planet Jr. seed drill. The overall rate of application of DDT, when applied in this manner, is calculated at 90 pounds to the acre.

Yield data collected from several of the treated plots showed that normal yields of 15 bushels per acre were experienced for the first time in 15 years from this symphylid infested soil.

Population counts showed a surprising reduction in numbers of symphylids in the DDT treated plots. (1.6 per sq. ft. for treated plots as contrasted with 45.2 for check plots.)

Subsequent small scale tests were attempted to study the time-mortality of DDT against symphylids. These tests were limited in scope but approximately three hours is indicated as the time required to effect complete kills.

Broadcasting of three per cent DDT dust (Geigy) and tilling the material into the soil at the rate of 145, 220 and 366 pounds per acre (4.35, 6.60 and 10.96 pounds per acre actual DDT) resulted in no apparent reduction in symphylid population.

There was no evidence of plant injury from these DDT seed treated plots although the rate of germination was retarded approximately two days.

[1] Published as Technical Paper No. 402 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution of the Dept. of Entomology.

DDT to Control Cabbage Caterpillars

J. W. APPLE, *Illinois Natural History Survey, Urbana*

Several workers have shown that DDT (2,2-bis (parachlorophenyl) 1,1,1-trichloroethane) is highly toxic to caterpillars attacking cabbage. Swingle & Mayer (1944) reported a 3 per cent DDT dust giving 100 per cent control of fourth instar cabbage loopers and cross-striped cabbage worms in two days under laboratory conditions. Smith & Harrison (1944) found a 10 per cent DDT dust to be very effective on the common cabbage caterpillars under field conditions. Harrison (1944) found in laboratory tests that 10 per cent DDT was less toxic to imported cabbage worms than 0.75 per cent rotenone dust. Against the cross-striped cabbage worm the DDT dust was more toxic than the rotenone.

A small plot experiment was conducted in Urbana, Illinois, during 1944 to evaluate different concentrations, formulations, and number of applications of DDT dust. A plot consisted of a single row 36 feet long. Each treatment was replicated three times in the randomized design. Applications were made August 25 and September 2, 12, and 24. Rainfall amounted to 2.27 inches on the first application, 0.97 inch on the second, 0.92 on the third, and 2.22 inches between the fourth application and October 9 when records were taken.

Results, table 1, are based on the relative amount of leaf feeding on October 9, each plant being given a value based on the amount of feeding or lack of it, as follows: 0, clean; 1, slight feeding; 2, moderate; 3, severe; and 4, very severe feeding. The caterpillar infestation was not severe, as six untreated plants scattered throughout the field had an average leaf injury rating of 1.83. Cabbage loopers, *Autographa brassicae* (Riley), were more prevalent than imported cabbage worms, *Pieris rapae* (L.), or diamond-back moth larvae, *Plutella maculipennis* (Curt.).

Table 1.—Relative effectiveness of DDT dusts against cabbage caterpillars.

Treatment	Rate of Application per Acre, Lbs.	Average Leaf Damage	Number of Plants in Count
DDT 3 per cent			
4 applications	33.5	0.01	67
3 applications	33.5	0.20	73
2 applications	29.5	0.69	82
1 application	29.5	1.27	65
4 Applications			
Rotenone (standard) 0.5% DDT, 1%	37.5	0.11	87
Mechanical mix	37.5	0.10	70
Dissolved in acetone, impregnated on 3% of *Pyrax*	35.5	0.03	74
Dissolved in Velsicol AR 60, impregnated on 50% of *Pyrax*	38.9	0.00	73
	38.9	0.00	73
Difference for significance		0.28	
Difference for high significance		0.38	

Abundant rainfall and rapidly growing plants greatly reduced the residual effect of DDT. We can expect cabbage plants to expose unprotected foliage so rapidly as to require a full complement of treatments under severe worm infestations.

Three per cent DDT dust gave very superior control of cabbage caterpillars. A 1 per cent mechanically mixed DDT dust did not give quite as good results but it was commercially satisfactory under the mild degree of insect infestation. The two formulations of 1 per cent DDT dust with a solvent gave good results and they offer real promise as a means of reducing the concentration of toxicant and still retaining a high level of toxicity.—2-19-45.

LITERATURE CITED

Swingle, M. C., and E. L. Mayer. 1944. Laboratory tests of DDT against various insect pests. JOUR. ECON. ENT. 37(1): 141–2.

Smith, C. E., and P. K. Harrison. 1944. Field tests with DDT and other insecticides against cabbage caterpillars. JOUR. ECON. ENT. 37(1): 152–3.

Harrison, P. K. 1944. Tests of DDT for cabbage insects and squash bugs. JOUR. ECON. ENT. 37(1): 153–4.

DDT Ineffective for Control of an Exotic Earthworm

W. E. FLEMING AND C. H. HADLEY, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

For several years an exotic earthworm, probably *Pheretima hupeiensis* Michaelson, has been causing damage to a 36-hole practice green of a golf course near Rye, N. Y. In the spring of 1944 it was estimated that the density of the population in the green was about 25 worms per square foot. As many as 15 gallons of worms have been removed from the green at one time without causing a noticeable decrease in the population. With the large number of casts thrown up daily and with the worms crawling on the surface of the green, it has been exceedingly difficult to maintain the green in a satisfactory condition for playing.

For several years excessive amounts of lead arsenate, calomel, mercuric chloride, mowrah meal, and other materials, which are usually effective in controlling earthworms, have been applied without success for the control of this pest. In view of the favorable results obtained with technical DDT against the larvae of the Japanese beetle, *Popillia japonica* Newm., it was decided to try this chemical for the control of the worms.

A preliminary test was made in the laboratory to determine the reaction of the worms to DDT. When a 10-per cent DDT powder was sprinkled on the worms, they became violently agitated but few of them died. The material was then mixed intimately with soil at the rates of 25 and 50 pounds per acre, and 25 partially grown worms were introduced into each treated lot. The 50-pound treatment killed all the partially grown worms in 4 days, and the 25-pound treatment killed them all in 26 days. When this test was repeated with full-grown worms, the 50-pound treatment had no effect on them during a period of 56 days. It was evident that the full-grown worms were very resistant.

Two quarter-acre plots were laid out on the practice green on May 24 and treated with DDT at the rates of 25 and 50 pounds per acre. The material was applied as a 2.5-per cent dust with a small fertilizer distributor. A month later the amount of DDT in half of the plot given the 25-pound treatment was raised to 100 pounds per acre. The worms were kept active and near the surface throughout the summer by frequent watering. This green was examined periodically throughout the summer. By the last of September, when the worms naturally tend to become inactive near the surface, there was no evidence that DDT, even at the rate of 100 pounds per acre, had caused any noticeable reduction in the number of worms.

These preliminary results suggest that DDT, at the rates and in the form used, is of little value for the control of this exotic earthworm in golf greens.—2-22-45.

REVIEW

BIBLIOGRAPHY OF BIOGRAPHIES OF ENTOMOLOGISTS. By Mathilde M. Carpenter. Reprinted from "The American Midland Naturalist," Vol. 33, p. 1–116, Jan., 1945. The University Press, Notre Dame, Indiana. $0.75 postpaid.

It is a pleasure to note the publication of this carefully prepared, extensive bibliography of the biographies of entomologists the world over. A work of this nature has been greatly needed for some years, especially by those interested in the history of entomology, and this is the first bibliography of its kind to appear since the publication of J. S. Wade's highly useful *Bibliography of Entomologists* in 1928 (Ann. Ent. Soc. Amer., 21:489–520).

There must be the names of at least 2,400 entomologists in Miss Carpenter's book, and the references to each name, which vary from one to many, include obituaries, birthdays, portraits, anniversaries, biographies and dispositions of collections, involving an enormous amount of careful work. Entomologists are lucky in having much of their bibliographical work done for them by public spirited persons working in their spare time, or by bibliographers who are on the payrolls of other agencies. Sometimes I wonder what they would do if they had to pay for all this work. Not having to pay for it, they should at least adequately support the finished products, when they appear, but they even fail in this respect.

The present bibliography is unusually complete. It is difficult not to miss a few names and the omissions which I am noting below are mentioned only because the author has asked to be notified of them.

Peter Cramer, author of "Papillons exotiques des trois parties du Monde, 1779–1782, in Dutch and French.

J. R. Forster, author of "Novæ Species Insectorum Centuria I," London, 1771, and a "Catalogue of British Insects," Warrington, 1770.

J. Casp. Fuessly, author of "Archiv der Insekton geschichte," 1781–1786.

Aroid David Hammel, author of "Quelques Observations sur la Blatte Germanique," Petersburg, 1821, and entomological essays fom 1821 to 1827.

John Christian Schoeffer, author of "Icones Insectorum circa Ratisbonam Indigenorum," 1769.

Frederick Weber, author of "Observationes Entomologicæ," Kiel, 1801.

Benjamin Wilkes, who published "One hundred and twenty copperplates of English Moths and Butterflies," London, 1773.

It may very well be that the omission of these early workers is due to the absence of biographical references to them. Their absence does not detract in the least from the great value of the bibliography, which will be utilized and appreciated for many years to come.—HARRY B. WEISS.

JOURNAL OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists

Vol. 38 June, 1945 No. 3

"The Hand Is Called"

Elsewhere in this issue will be seen a note to the effect that the publication funds of the JOURNAL have been augmented by a very generous gift from a friend of the profession. The donor had nothing to gain from this gift. The only personal payment possible, the goodwill of the profession of entomology, he had already. Until such time as a more formal and official recognition of this very generous gift can be made the JOURNAL will extend to Dr. Hyman the thanks and sincere appreciation of the Association.

But this does not end the matter; nor will the formal acknowledgment through more official channels, later, do so. Acceptance of a gift such as this places the Association and the entomological profession under an obligation, not to Dr. Hyman alone but to themselves and to the public which they serve as well.

A few days ago Professor J. J. Davis called our attention to a quotation attributed to Theodore Roosevelt which goes as follows: "Every man owes some of his time to the upbuilding of the profession to which he belongs." And, a few months ago Professor Davis published, as an editorial in the JOURNAL some thoughts along that same line. Entomologists, being human, are very much interested in what their pfoession will do for them; and, still being human, they tend to forget to ask themselves what they can do for the profession.

Thoughtlessness is undoubtedly responsible for most of the neglect of our opportunities to further our profession as a whole rather than just our own particular work. But there may be, at times, a still deeper reason. Lack of faith in the profession—any profession, is fatal. Perhaps some of us tend, at times, to lose some of our faith in the worthwhile nature of our work and of that of our associates. And perhaps the reason for this, one reason at least, may be that we are too close to it to get the proper perspective.

Perhaps it is necessary for us to have the very concrete evidence of a disinterested outsider to restore our own faith. A careful survey of the possible motives back of the gift to which reference has been made fails to show any reason why this gift should have been made other than a very definite FAITH in the profession. May it not be that the spiritual returns from the gift can exceed the material gains? It lies with us to determine this and also to show our appreciation to Dr. Hyman in the only possible way, by using the fund to publish some things which shall be truly worth while and which we should otherwise have been unable to publish.

In editorials and in discussions of postwar needs in entomology, increased publication facilities have been stressed. It has been pointed out that present facilities are inadequate for our needs and various suggestions for increasing them have been made.

It seems to the writer that this gift amounts to a direct challenge to us to demonstrate the truth of the contention. And that the only way in which this can be done is for us to produce, from some source, material for publication which will be of sufficient merit and permanent importance to justify the use of the fund. We must not use it for anything trivial or of temporary value. It must produce a definite addition to the literature of the science of entomology. Is there awaiting publication, or nearing completion, any work in our field for which we can properly use the fund? The hand is called; it is up to us to show that the donation is justified.

And, if we *do* produce an outstanding publication under the stimulus of the gift it is entirely possible that other friends of entomology will be prompted to express their faith in the profession and goodwill towards its members in a similar fashion. It is up to us.

A Gift to the Association

The following note has recently been received from Dr. George C. Decker:

"Some time ago Dr. Julius Hyman, of the Velsicol Corporation of Chicago, in appreciation of the work being done by the entomologists of the country, presented to Dr. T. H. Frison a generous check to be used in the publication of especially worthy entomological papers.

Dr. Frison has divided the fund equally between our two major societies and has requested that I transmit to you the enclosed cashier's check for $500.00 with the stipulation that this special fund be held for use in the publication of some book, monograph, comprehensive treatise or to aid in the publication of especially worthy or extraordinary large papers in the Journal itself.

"This gift by Dr. Hyman was perhaps intended to be from an anonymous donor, because I am quite certain he did not covet publicity. At the same time, I do not feel that a note of appreciation would be out of order."

Review

The Mosquitoes of New Jersey and Their Control. Thomas J. Headlee. 326 pp., 87 figures, 16 plates. Rutgers University Press, New Brunswick, N. J.

For many years New Jersey has led the parade of states in the control of mosquitoes, especially salt marsh species. Naturally when a book appears summarizing the mosquito studies made in New Jersey for more than forty years one anticipates finding much valuable information therein. In many respects this book by Dr. T. H. Headlee and his cooperators fills the bill; however, there are some phases of mosquito work which might have been presented more extensively and carefully.

One of the serious faults of the book is the omission of an index. The reviewer has tried to locate information which is in the book and has spent much time thumbing the pages to find it. A good index is a prerequisite for a useful reference book. Some of the information is not as well organized as it might have been. For example, if one wishes to locate detailed information on the construction, use and results obtained with the valuable mosquito trap developed in New Jersey the information is located in several places. The lack of an index also complicates the problem of finding this information.

The book makes available again the excellent observations recorded by John B. Smith in Chapter 4, pages 33 to 231. Comparatively few changes or new additions are made beyond the original notes of John B. Smith and his assistants.

Dr. Headlee's major contribution was in the field of mosquito control. He had outstanding ability to interest people in mosquitoes and to establish and maintain mosquito commissions in various counties throughout the state. More specific details on how each county was organized and how the work was conducted might have been presented which would have been very useful for other states conducting or contemplating mosquito control. Much interesting and valuable information produced by Dr. Headlee and his assistants is presented in Chapters 5 to 11, pages 232–323. In addition to the figures prepared and used by John B. Smith there are 16 plates of good photographs illustrating several phases of mosquito control.

In spite of a number of faults, chiefly omissions, the book is an important contribution to the biology and control of mosquitoes, especially salt marsh species.—A.P.

The Biometrics Bulletin

This year the American Statistical Association is launching, for its Biometrics Section, a new journal, the Biometrics Bulletin. It is to appear six times a year, is to contain at first 12 to 16 pages, and will include news notes, abstracts, a "queries department," and a few short articles of general interest and scope. The editorial committee, headed by Gertrude Cox and including C. I. Bliss, W. G. Cochran, F. R. Immer, J. Neyman, H. W. Norton, L. J. Reed, G. W. Snedecor, and Sewall Wright, is in itself a guarantee of quality and usefulness.

Members of the association and section will receive the Bulletin. Persons not members of the association may be members of the Biometrics Section, paying dues of $2.00 per year and receiving the Bulletin. Non-members may subscribe for $3.00 per year; single numbers are 60¢. Applications should be sent to the American Statistical Association, 1603 K. St. N.W., Washington, D. C.

The launching of the Bulletin is a fulfillment of the hopes of many who have been working for more exact comparisons in biology. The quality of the first two numbers is gratifying. We hope that entomologists will have a share in the use of this medium, along with agronomists, geneticists, foresters, physicians, animal husbandmen and other users.

F. M. Wadley, *Statistical Consultant*
Bureau of Entomology and Plant Quarantine

"Insect Control: Insecticides and Fungicides"

A chapter under this heading appears in "The Chemistry and Technology of Food and Food Products" edited by Dr. Morris B. Jacobs of the New York City Department of Health. This chapter was written by Dr. Harold H. Shepard, at that time of the University of Minnesota.

Attention is called here to the article named because entomologists who might well be interested will tend to overlook it in the monumental work in which it appears. Unfortunately, this consists of two volumes of some 1900 pages and is correspondingly expensive. It is, however, a work which should be found in most libraries where entomologists may take opportunity to consult it. Those who do so are warned that they are likely to consume considerable time browsing through the work which is well written and contains a mass of material, most of which will prove of interest to the person who uses the book for reference.

OBITUARIES

Louis M. Scott, 1886-1944

Louis M. Scott was born in Logansport, Indiana, March 4, 1886, and died on October 14, 1944, at his home in Laurelhurst, Seattle, Washington. At the time of his death he was in charge of the foreign plant quarantine work of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, in Seattle, Washington.

His early education was obtained in Reedsburg, Wisconsin, and in 1909 he received the degree of Bachelor of Arts at Lake Forest College. Subsequently he received the degree of Bachelor of Science in Horticulture at Winona Agricultural College and took postgraduate courses at Purdue University and Oregon Agricultural College.

After several years of management and ownership of orchards, he in 1918 became associated with the International Harvester Company and was engaged in making a field study of flax culture in North Dakota and Minnesota. On January 2, 1920, he was appointed plant quarantine inspector in the Federal Horticultural Board and assigned to the port of Boston. He quickly demonstrated a keen and far reaching interest in foreign plant quarantine work which, at that time, was just beginning to develop momentum. Because of demonstrated ability, energy and imagination he was selected to pioneer a number of activities which today, as the result of his early efforts, are successful operations. In handling these important problems he was successively stationed at the following important ports of entry; Chicago, Ill.; Washington, D. C.; New York, N. Y.; Rouses Point, N. Y.; Baltimore, Md.; and Seattle, Washington. His 24 years in his chosen field were full of activity and accomplishments. He was a man of staunch loyalty and possessed an excellent personality and sense of humor which made for him lasting friends, not only among his associates but in other governmental agencies and in his contacts with the public in general.

His interests were broad in civic affairs and in recent years he was actively engaged in Civilian Defense, Boy Scouts, and War Dads Association. He was prominent in the first two named, in which he gave of himself without stint. His principal hobby was in the growing of tuberous begonias, but his horticultural accomplishments were not confined to flowers for he was successful in the production of small fruits and Victory Gardens. His chief interests, however, were his home, family, friends, and neighbors. They were his life, and his religion was made manifest in the many ways he served and loved his fellow man.

Besides his wife, Neva, he leaves two sons, one of whom is in the army.

E. R. Sasscer

John D. Maple II, 1910-1945

John Dinwiddie Maple II, Lieutenant (s.g.) United States Naval Reserve was killed in an airplane crash in the Pacific war theater April 11, 1945. Lt. Maple was born in Whittier, California, December 14, 1910. After graduating from Pomona College in 1932, he studied for his master of science degree at the University of California at Berkeley, graduating in 1934.

Maple served as Assistant Entomologist with the Division of Foreign Parasites Introduction at the Yokahoma, Japan laboratory of the U. S. Department of Agricutlure from 1938 through 1941. He received his Ph.D. degree from the University of California at Berkeley in 1940 while serving in Japan.

Maple was taken prisoner and interned in December 1941 by the Japanese. He was repatriated and returned on the exchange ship *Gripsholm* in 1942.

Upon his return to the United States in August, 1942, he was employed as Assistant Entomologist at the Laboratory of the Bureau of Entomology and Plant Quarantine in Orlando, Florida. At Orlando he was closely associated with the development of DDT for the control of malarial mosquitoes.

Lieutenant Maple was commissioned April 4, 1944 to conduct malaria control work in the war theaters and it was while carrying out this important work in the approaches to Japan that he was killed.

He was a member of Sigma Xi, American Association of Economic Entomologists, American Association for the Advancement of Science and the Washington Entomological Society.

Lieutenant Maple is survived by his parents, Mr. and Mrs. Amos C. Maple of Whittier, California; a grandmother, Mrs. J. H. Neurlin; and four sisters, Mrs. Bewley Allen of Whittier, Miss Margaret Maple of Claremont, Mrs. Mason Hill of Bakersfield, and Mrs. Edward Kraeger of Whittier.

C. C. Deonier

NOTES

North Central States Entomologists Meeting

The North Central States Entomologists Conference came to an end with its 24th session held at Purdue University, March 29 and 30. Since 1921 entomologists of the north central states have met to discuss informally their problems, results of research, and plans for the coming year. From a group of seven from Ohio, Indiana, Illinois and Missouri (S. A. Forbes, W. P. Flint, W. H. Larrimer, T. H. Parks, H. A. Gossard, L. Haseman, and J. J. Davis) that met at Lafayette, Ind., in 1921, it has extended its scope and attendance to some 12 or 13 states and 200 attending. Because of O.D.T. regulations it was necessary to limit attendance to 50. As a result, the actual attendance was 61, 46 of whom were from outside Lafayette, the local entomologists not being included in the limited attendance.

Because of the restricted attendance, the program was limited to the major insect problems of the mid-west. Five sessions were held with the major problems discussed and chairmen of the sessions as follows:

Chinch Bug—George C. Decker
European Corn Borer—W. G. Bradley
Vegetable Garden Insects—Ray Hutson
Codling Moth—L. F. Steiner
Insecticides and Appliances—Harold Waters

Although those attending the conference were unanimous in maintaining an informal conference, prepared papers for reading being prohibited, it was felt it would be desirable, for various reasons, to organize as an association with elected officers. As a result, the group organized as the North Central States Entomologists Association and the first officers were named. J. J. Davis of Purdue University was elected president and M. D. Farrar of the Illinois Natural History Survey was elected secretary. Whether or not the newly organized association will seek admission as a branch of the American Association of Economic Entomologists will depend upon a mail ballot to be made. The 1946 meeting will be held at the University of Illinois, Urbana, Ill.

Nineteenth Annual Western Cooperative Spray Conference

The Nineteenth Annual Conference of the Western Cooperative Spray Project was held at Walla Walla, Washington, on January 24 and 25. This is an official conference of entomologists, chemists, plant pathologists and horticulturists engaged in state or federal research work on orchard spraying problems in the West. The membership includes men from the experiment stations of Washington, Oregon, California, Idaho, and Montana, the Bureau of Plant and Insect Control of the Colorado Division of Agriculture, the Canadian Department of Agriculture, and the U. S. Department of Agriculture.

There were discussions of research work on dormant sprays, and on sprays for the codling moth, mites, cherry fruit fly, pear thrips, pear psylla, filbert insects and scab and mildew. Much of the discussion centered around the tests that had been made of DDT and on plans for future work with it. The annual suggestions for the use of orchard sprays, which is used by some of the states as a basis for their own recommendations, was brought up to date, the principal change being a liberalizing of the suggestions for using cryolite, as a result of the higher residue tolerance now allowed, and a warning to use care in spraying in order to avoid poisoning honey bees.

The conference adjourned at noon of the second day for a group luncheon with representatives of insecticide manufacturers and distributors, field men of growers' organizations, horticultural inspectors and county agents. Afterwards a joint meeting was held, presided over by Ed Littooy of the Colloidal Products Corporation, at which discussion centered around the availability of insecticides and fungicides. There was an attendance of 93 members and visitors at the joint meeting.

The following members of the Spray Project were in attendance:

Idaho:
W. E. Shull
Leif Verner

Oregon:
Leroy Childs
L. G. Gentner
S. C. Jones
Robt. E. Rieder
R. H. Robinson

Washington:
Kermit Groves
J. D. Menzies
W. J. O'Neill
E. L. Overholser
F. L. Overley
L. G. Smith
J. C. Snyder
J. L. St. John
K. C. Walker
R. L. Webster

U.S.D.A.
F. W. Carlson
F. P. Dean
S. M. Dohanian
K. A. Haines
T. L. Kirkpatrick
E. J. Newcomer
W. E. Westlake
M. A. Yothers

E. J. Newcomer, Yakima, Wash., was Chairman of the conference, and F. L. Overley, Wenatchee, Wash., was Secretary.

F. L. Overley, *Secretary*

Fourth Annual Meeting of the Northwest Vegetable Insect Control Conference

The fourth annual meeting of the Northwest Vegetable Insect Control Conference was held in Walla Walla, Washington on January 16 and 17, 1945. Entomologists from the Northwest states of Idaho, Oregon, Montana, and Washington were in attendance. As in previous conferences new developments in the control of the principal vegetable insect pests in the Northwest were discussed informally. J. R. Douglass, R. E. Rieder, and T. A. Brindley acted as discussion leaders. The meeting was divided into four sessions: At the first, the work in progress with DDT was reviewed, during the second, other research on vegetable insects was discussed, at the third session during which representatives of the insecticide industry were present, the insecticide supply situation was reviewed, and the fourth session was devoted to business.

Two talks were presented at the Annual Banquet. These were: "Highlights of the Annual Meeting of the American Association of Economic Entomologists and the American Entomological Society" by L. G. Smith, and "New Developments in Vegetable Insect Control" by D. J. Caffrey.

The following members attended the conference:

E. P. Breakey	Puyallup, Washington
Tom A. Brindley	Moscow, Idaho
D. J. Caffrey	Washington, D. C.
E. C. Carlson	Mt. Vernon, Washington
M. C. Cook	Walla Walla, Washington
D. J. Cromley	Long Beach, Washington
C. F. Doucette	Sumner, Washington
J. R. Douglass	Twin Falls, Idaho
E. B. Hastings	Bozeman, Montana
J. Hooper	Pendleton, Washington
E. W. Jones	Walla Walla, Washington
H. P. Lanchester	Walla Walla, Washington
B. J. Landis	Union Gap, Washington
H. C. Manis	Moscow, Idaho
H. E. Morrison	Corvallis, Oregon
T. E. Randall	Mt. Vernon, Washington
W. E. Shull	Moscow, Idaho
L. G. Smith	Pullman, Washington
R. E. Rieder	Corvallis, Oregon
C. L. Vincent	Pullman, Washington
C. S. Wood	Pendleton, Washington

The executive committee in charge of arrangements for the 1945 meeting were H. B. Mills, Montana State College, Bozeman, Montana, Chairman: J. R. Douglass, U. S. Department of Agriculture, Twin Falls, Idaho, Co-chairman; and Tom A. Brindley, U. S. Department of Agriculture, Moscow, Idaho, Secretary. M. C. Lane and W. C. Cook were in charge of local arrangements.

The following executive committee was elected for the coming year: Don C. Mote, Oregon State College, Corvallis, Oregon, Chairman; E. P. Breakey, Western Washington Experiment Station, Co-chairman; and Tom A. Brindley, Moscow, Idaho, Secretary.

TOM A. BRINDLEY
Secretary

LABELING INSECTICIDES CONTAINING DDT

The term "DDT" refers to the technical grade of 2,2-bis (parachlorophenyl) 1,1,1-trichloroethane, which contains as impurities considerable amounts of isomers and much smaller amounts of other by-products formed in its manufacture. So far as we are now aware, the normal impurities in DDT are active ingredients within the meaning of the Insecticide Act of 1910. Therefore, its label is not required to bear an ingredient statement.

When DDT is applied as an insecticide, it is mixed or compounded with other materials to make it suitable for application. If all of the ingredients are active, no ingredient statement is required to appear on the label, but if any of the added ingredients are inert—that is, if any of them are not in themselves insecticides for the purposes intended—the label is required to bear the name and percentage amount of each and every inert ingredient or, in lieu of this, the name and percentage amount of each and every active ingredient, together with the total percentage of the inert ingredients. The ingredient statement is required in the case of shipments of insecticides intended for experimental use, as well as those made for commercial use.

There is at the present time no practical method of determining all of the different compounds in DDT. In view of this, no objection is raised to considering dichloro diphenyl trichloroethane (which includes 2,2-bis (parachlorophenyl) 1,1,1-trichloroethane and its isomers) as the active ingredient. For a preparation containing DDT as its only active constituent, the following form of ingredient statement, which should appear prominently on the front panel of the label, will be acceptable:

ACTIVE INGREDIENT	
Dichloro diphenyl trichloroethane	—%
INERT INGREDIENTS	—%
Total	100%

the correct values to be inserted in the blank spaces. If other active ingredients are present, the ingredient statement should be changed to show the names and percentages of each such added active ingredient.

The amount of DDT which has been available for experimental work in agricultural and civilian fields has been limited and even now it is restricted to experimental use. The Bureau of Entomology and Plant Quarantine and entomologists have not issued recommendations for commercial use; therefore, we are not in position to indicate any directions for use which would be acceptable under the provisions of the Insecticide Act. There is no provision in the act which prohibits the appearance on the label of recommendations for use which are not false or misleading but none should be made unless based on the results of adequate tests to determine not only its efficacy but also the harmful effects on man, domestic animals or plants, if any, that it may have when used as directed.

The Insecticide Act does not require poison labeling but since the use of DDT involves certain hazards, products containing it must not be labeled so as to state or imply that they are safe or non-poisonous. Furthermore, it is desirable that the labels of insecticides containing DDT bear a caution to avoid personal injury. Such caution should provide for avoiding skin contact, avoiding inhalation of the dust or spray, and keeping the material from all contact with foods. The caution statement should be set out prominently so that it will come to the immediate attention of the user.—4-18-45.

W. G. REED
Chief, Insecticide Division
Livestock and Meats Branch